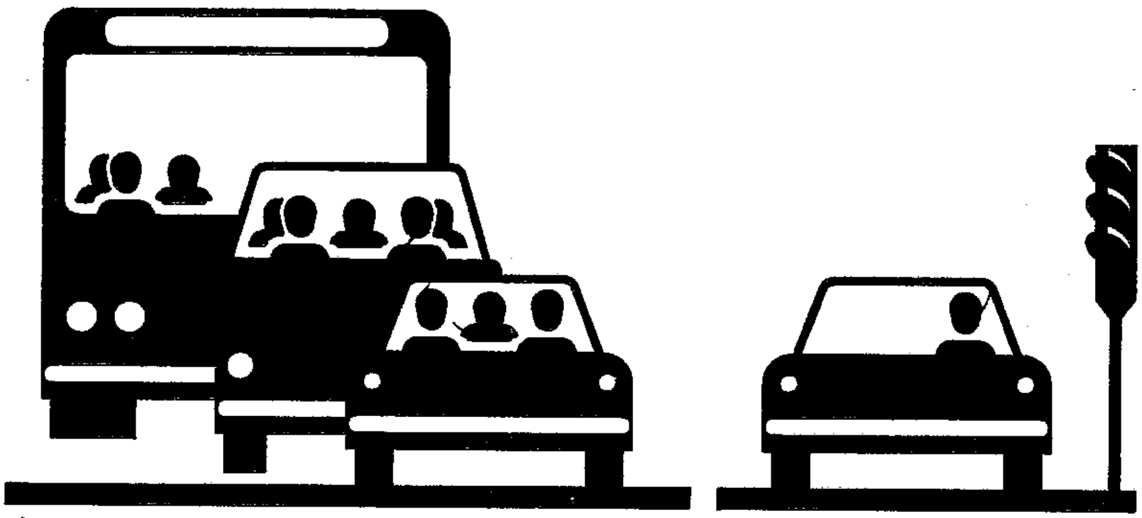
SR-167

15TH STREET S.W. TO SOUTH GRADY WAY

Bridge Foundation Report



- HOV Improvements
- Ramp Metering
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Washington State
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TERRA ASSOCIATES, Inc.
Consultants in Geotechnical Engineering, Geology
and
Environmental Earth Sciences

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and
Environmental Earth Sciences

December 8, 1992
Project No. T-1630

Mr. Tom Murawski
Alpha Engineering Group
16040 Christensen Road, Suite 305
Seattle, Washington 98188

Subject: Bridge Foundation Report
Highway 167 Widening
15th Street SW to South Grady Way
King County, Washington

Dear Mr. Murawski:

As requested, we have revised the Bridge Foundation Report to incorporate our responses to WSDOT comments regarding pile capacities and large-diameter shafts, and to the pile downdrag implications of the embankment widenings planned at Meeker Street and at the BNRR overcrossing. In addition, we have added an Appendix C containing WSDOT boring logs we used in our studies. This revision supersedes all copies of the report with earlier dates.

We trust the information presented in this report is sufficiently detailed for your interpretation and use. Please call if you have any questions.

Sincerely,

TERRA ASSOCIATES, INC.

12/8/92

Anil Butail, P.E.
President

EXPIRES 12/09/93

BB/TJS/AB:tw

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TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

Tables

Figures

Appendices

Bridge Foundation Report
Highway 167 Widening
15th Street SW to South Grady Way
King County, Washington

1.0 INTRODUCTION AND SUMMARY

In this project, eight pairs of existing SR 167 overpass bridges located between SR 18 in Auburn and 84th Avenue South in Kent will be widened. A ramp bridge at SR 18 and another at South 212th Street also will be widened. In general, the new lanes will be constructed within the highway median strip. To accommodate wider entrance and exit lanes, the outside shoulders of several bridges also will be widened. Additions to the bridges will be supported on new piers and foundations.

Nearly all the existing bridge piers are supported on pile foundations. The only exceptions are the abutment piers at the SR 18 bridges. These are spread footings bearing on the approach embankment fills. Elsewhere, both timber piles and cast-in-place concrete piles with driven steel shells have been used to support pier foundations. To the best of our knowledge, the performance of all piles has been satisfactory. We know of no reported abnormal behavior and none was noticed by us when we explored these locations.

Based on our explorations and our review of prior driving records, we recommend supporting the pier foundations on cast-in-place concrete piles with driven steel pipe shells. In addition, we recommend batter piles for resisting lateral earthquake loads. Other alternatives may be considered.

2.0 SCOPE OF WORK

The scope of work performed by us in conducting this study and preparing this report included the following items of work:

1. **Review of Existing Information** This information included logs of previously drilled borings, drawings of existing bridges, and records of previous pile driving operations. Complete information for all existing bridges was not available. Logs of previous borings are referenced in Appendix C (Volume 2).

2. **Subsurface Exploration** Subsurface exploration consisting of drilling 20 test borings to a maximum depth of 119 feet below the existing ground surface. Details of the subsurface exploration program are presented in Appendix A.

3. **Laboratory Testing** We performed laboratory tests on many samples to determine the pertinent physical and engineering characteristics of the soils underlying the bridge locations. Details of the laboratory testing and the test data are presented in Appendix B.

4. **Engineering Analyses and Evaluations** Based on the field and laboratory test data and correlation with records of previous pile installations, we conducted analyses and evaluations to develop criteria for design of foundations at each new bridge.

5. **Design Report** Based on our studies, we have prepared this report which presents our findings and evaluations along with our recommendations for design of the new bridges.

6. **Project Meetings** During the performance of our study, we met with representatives of Alpha Engineering Group to discuss our proposed plan of action as well as to present our findings.

3.0 SITE GEOLOGY

The Green-Duwamish River Valley is located in the central Puget Sound Lowland physiographic province. The geology of the Puget Sound Lowland is the product of several complex geologic processes extending over a long period of time. These events were summarized in their order of occurrence in a study prepared for Metro, entitled Duwamish Groundwater Studies.

1. Submergence of the region under shallow seas from the Cambrian Period to the early Mesozoic Era - 600 to 200 million years ago (mya).

2. Marine and continental volcanism during the Mesozoic - 224 to 65 mya.

3. Retreat of the seas as the continental land mass slowly rose during the late Mesozoic - 150 to 65 mya.

4. Mountain building resulting from folding and faulting of the crust contemporaneous with volcanism and lava flows in the early Tertiary Period - 65 to 40 mya.

5. Uplift of the present Cascade and Olympic Mountains beginning in the Pliocene Epoch - 7 mya and continuing through the present.

6. Advances and retreats of the continental ice sheets during the Pleistocene Epoch - 2.5 mya to 11,000 years ago.

7. Incision of valleys and the subsequent deposition of alluvial deposits in recent time - 11,000 years ago to the present.

In general, four major geologic units were encountered by our explorations of the Green-Duwamish River valley floor along the State Route 167 corridor. These are: artificial fill, alluvium, estuarine deposits, and bedrock.

Artificial Fill: These are materials placed by man, primarily imported pit-run gravelly sand used to construct roadway fills and bridge ramps, but also including fine-grained dredged sediments such as sand and silt. Character of the fill can change laterally and vertically over short distances.

Alluvium: Present throughout the valley floor, including the State Route 167 corridor. Alluvium consists of interfingered strata of sand, silt, clay, gravel, and peat. Because depositional channels have shifted, individual beds of uniform grain-size are not laterally continuous over large areas, and interfingering of different strata is common. Thickness can vary from several feet to several hundred feet.

Estuarine Deposits: These vary in composition from clayey silt to sand and gravel. Shells are typical and thickness ranges from a few feet to as much as 90 feet. Deposits vary laterally and vertically, commonly grading finer with depth.

Bedrock: Sandstones and siltstones form the ridge on the southeast side of the valley, but plunge to considerable depth within the valley floor. The sandstones and siltstones are typically hard. Bedrock was encountered only at the South 212th Street intersection and consisted of siltstone.

4.0 SITE CONDITIONS

4.1 General

The locations of the various bridges are shown on Figure 1. Layouts of existing bridges and the proposed widening are shown on Figures 2 through 11. These drawings also show the locations of test borings drilled for this study at each bridge site. Subsurface profiles have been prepared across the bridge sites and are shown on Figures 12 through 21.

In general, the existing bridge structures have been constructed by placing approach embankments up to approximately 40 feet high leading to bridge abutments at the ends. The abutments as well as center supports of the bridges are typically supported on timber or cast-in-place concrete (steel pipe) piles. Details of existing surface and subsurface conditions at each bridge location are discussed in the following paragraphs.

4.2 State Route 18 Bridges (Figures 2 and 12)

State Route 167 crosses State Route 18 in Auburn, south of Main Street. At this location, SR 18 has six to eight lanes and is oriented east-west. The bridge overpass alignment is north-south. The existing overpass consists of three separate bridge structures, two providing for two traffic lanes, the third serving as an on-ramp to northbound SR 167. No shoulder is provided on the bridges.

The abutment piers on all three bridges are spread footings supported on 25 to 30 feet of fill and proportioned for maximum bearing stresses of 6000 pounds per square foot. The four interior piers at each bridge are supported on 12.75-inch pipe piles designed for allowable loads of 55 tons.

Pile lengths on the existing bridges, sometimes under the same footing, vary by as much as a hundred feet. Piles that failed to take up in the upper sands readily penetrated the silt and stopped on dense gravels at about Elev. -45. As additional piles were driven, the upper sands densified and the piles tended to take up at higher elevations.

Based on plans provided to us, we understand that a high-occupancy vehicle (HOV) lane is to be constructed for the northbound direction of State Route 167. The EWN Ramp is also to be widened. Widening of the mainline portion of the highway at this location will take place within the highway median. The ramp bridge will also be widened on the east side to facilitate the additional lanes.

Two test borings (B-9 and B-10) were drilled within the highway median, one at each end of the two mainline bridges. The borings encountered about 36 to 41 feet of medium dense to dense silty, gravelly sand fill used to construct the bridge ramps. The fill is underlain in the south boring location by about three feet of peat. Below the peat, and the roadfill in the north boring location, a layer of loose sandy silt three to ten feet thick was encountered.

The silt is underlain by medium dense to dense silty sand to the explored depth of 114 feet. A stiff to hard silt layer with some organics ranging from twelve to perhaps 20 feet thick was encountered at a depth of 92 to 101 feet within the silty sand unit.

4.3 Green River Bridges (Figures 3 and 13)

State Route 167 crosses Green River between SR 516 and South 277 Street in Kent. The river flows generally east to west. The bridge alignment is north-south. Each bridge supports two lanes of traffic.

Plans provided to us indicate that the two existing bridges, including the abutments, are supported on 27-ton timber piles. There are no batter piles. The interior piers are located on the river banks rather than in the water. Each interior pier is supported by a mat foundation bearing on 112 piles. The foundations were constructed inside cofferdams with concrete seals 2.5 feet thick. The bottom of the seals is at Elev. 14. Typical river stages are Elev. 28.

Pile driving records indicate that the piles drove easily with gradually increasing resistance. Most piles were driven to capacities in the range of 27 to 40 tons. Pile tip diameters ranged from seven to ten inches; most were in the range of seven to eight inches. Tip diameters do not correlate with driving resistance. Pile tips range from Elev. 10 to -37. Several piles that did not take up did not restart after being left for brief periods.

Construction of HOV lanes at this location will require widening the existing bridges within the median or the gap between the two bridges.

Subsurface exploration at this site consisted of drilling two borings (B-8 and B-11) located within the highway median, one at each end of the overpass. The upper nine to twelve feet of soil is roadway fill, mostly medium dense silty, slightly gravelly sand. The fill is underlain by three to eleven feet of loose sandy silt. Underlying the loose sandy silt, the borings encountered loose silty sand to a depth of 36 feet then medium dense to dense sands with occasional loose pockets to an explored depth of 104 feet. A layer of sandy silt six to seven feet thick was found at a depth of about 67 feet.

4.4 State Route 516 Bridges (Figures 4 and 14)

This bridge overcrosses SR 516 in Kent. SR 516 is a four-lane road oriented east-west. The SR 167 bridge overpass alignment is north-south. There are two separate bridge structures, each providing two traffic lanes. No shoulder is provided on either bridge. These bridges have a single interior pier in addition to the abutment piers. All piers are supported on 28-ton timber piles. There are no batter piles.

The bearing stratum here is medium dense to dense sand lying generally below Elev. 10. The piles stopped with their tips typically in the range of Elev. 12 to -9.

Based on plans provided to us, we understand that an HOV lane is to be constructed for both directions of traffic on SR 167. The bridges will be widened to the inside between the bridges to construct the additional lanes.

Two test borings (B-7 and B-12) were drilled within the highway median, one at each end of the bridges. The ground surface at both locations is approximately one to two feet below the level of the existing bridge decks. Both borings encountered about 25 feet of dense silty, gravelly sand fill used to construct the bridge approach embankments. The fill is underlain by approximately 20 feet of loose to stiff, silty, very fine sand and sandy silt. Underlying this soil unit is medium dense to dense silty sand with occasional silt layers and gravel layers, extending to an explored depth of 99 feet.

4.5 Meeker Street Bridges (Figures 5 and 15)

167/125 E

These bridges overcross West Meeker Street in Kent. Meeker Street is aligned in an east-west direction and the existing SR 167 overpass is aligned north-south. Each overpass bridge provides two lanes of traffic.

?? Test piles were driven to 55 to 55 tons.

These bridges each have two interior piers in addition to the two abutment piers. Plans provided to us indicate that all piers are supported on 27-ton timber piles with no batter piles.

TRY -7' to -20' (Test Piles)

The piles all stopped in the upper sands with their tips at Elev. 14 to -17. The piles generally drove easily. Three of nine piles under the center footing at Pier 3E did not fetch up above Elev. -10, as expected. One of these piles started immediately when redriven the next day. Consequently, two additional piles were driven to supplement the nine-pile cluster. Both piles reached capacity well short of Elev. -10.

Piles for Pier 3W were driven out-of-place about six feet east and apparently were not pulled. If the new pier is located 15 feet east of the existing east pier, as shown on preliminary sketches, the new piles should clear these mislocated timber piles. The old piles should be pulled if they interfere with the new construction.

Construction of HOV lanes at this location will require widening each of the existing bridges on both sides.

Subsurface exploration at this site consisted of drilling two borings (B-6 and B-13) within the highway median, one at each end of the overpass. The upper 21 to 22 feet of soil is the roadway fill consisting of medium dense to dense gravelly, silty sand. The fill is underlain by three to five feet of loose sandy silt.

El. 57', B-13 99' ∇ @ 30'
El. 57' B-6 94' ∇ @ 31'

Underlying the silt, the borings encountered loose silty sand to a depth of 42 to 48 feet. Below, medium dense to dense sands with occasional loose pockets were encountered to an explored depth of 104 feet. A layer of sandy silt six to seven feet thick was found at a depth of about 77 feet in the south boring.

4.6 James Street Bridges (Figures 6 and 16)

These bridges overcross James Street in Kent. The alignment of the surface street is east-west. The overpass alignment is nearly north-south. Each bridge provides two traffic lanes. No shoulder is provided on either bridge.

These bridges each have two interior piers plus the abutment piers. We understand that all piers are supported on 27-ton timber piles. There are no batter piles.

Three abutment piles refused with their tips as high as Elev. 24. The remaining piles stopped in the upper sands with their tips between Elev. 12 and -12. Piles for the interior piers drove easier than those for the abutment piers.

Based on plans provided to us, we understand that a HOV lane is to be constructed for both directions of traffic on State Route 167. Widening of the highway at this location will take place within the existing median. The existing bridges will also be widened between the bridges to facilitate construction of the additional lanes.

Two test borings (B-5 and B-14) were drilled within the highway median, one at each end of the bridges. The ground surface at both boring locations is approximately one to two feet below the level of the existing bridge decks. The north boring encountered 29 feet of silty, gravelly sand fill used to construct the bridge ramps and highway subgrade. The same fill in the south boring extended to a depth of about 22 feet.

The fill is underlain by seven feet of loose sandy silt. Underlying this soil unit is medium dense to dense silty sand with occasional silt layers, extending to an explored depth of 99 feet. A layer of loose sandy silt to clayey silt four to six feet thick was encountered at a depth of approximately 40 feet.

4.7 Union Pacific Railroad Overpasses (Figures 7 and 17)

State Route 167 crosses the Union Pacific Railroad between North 4th Avenue and Lincoln Avenue in Kent. There are two railroad tracks aligned in a north-south direction. The overpasses are aligned northeast-southwest. Each bridge has two travel lanes with no shoulders.

These bridges have two interior piers in addition to the abutment piers. We understand from drawings provided to us that all pier footings are supported on piles. The original design was timber piles. By a drawing revision, cast-in-place concrete piles were substituted. The pile shells used are not noted in the field logs, but likely were 12.75-inch steel pipe. Pile capacity is 40 tons. The abutments have wing walls, including a substantial retaining wall extending northward on the west side of the west bridge. Many of the abutment piles are battered.

Piles supporting the interior piers drove to tip elevations in the range of -17 to -21. Most of the abutment piles stopped at about Elev. 5. Nine of 16 batter piles under the retaining wall on Pier 4W stopped at Elev. 16 to 22.

Planned construction of HOV lanes for SR 167 will necessitate widening of the overpasses. Additions to both bridges will be constructed within the median or the gap between the bridges.

Two test borings were drilled in the highway median at each end of the overpass. Both borings encountered approximately 40 feet of dense fill consisting of silty, gravelly sand.

The fill is underlain by medium dense to dense silty sand, with an occasional loose sandy layer, to an explored depth of 99 feet. Two layers of loose sandy silt five to eight feet thick were encountered at depths of 57 and 77 feet.

4.8 Fourth Avenue Bridges (Figures 8 and 18)

These bridges cross North Fourth Avenue in Kent. North Fourth Avenue is aligned in a north-south direction and the SR 167 overpasses are aligned northeast-southwest. Each bridge supports two traffic lanes.

Plans provided to us indicate that the each of the two bridges has abutment piers and two interior piers, all supported on piles. Half the abutment piles are battered but no piles supporting the interior piers are battered. By a drawing revision, timber piles were replaced with 40-ton cast-in-place concrete piles.

Only four of 132 piles stopped in the upper dense sand layer near Elev. -10. The remainder drove through this layer and stopped uniformly in the upper few feet of the dense sand that lies below Elev. -20 to -30.

Construction of HOV lanes at this location requires widening the existing bridges. The planned addition to the bridges will be on the inside in the median or the gap between the bridges.

Subsurface exploration at this site consisted of two borings (B-3 and B-16) located within the highway median, one at each end of the overpass. The upper 26 feet of soil is roadway fill consisting of medium dense to dense gravelly, silty sand. The fill is underlain by four to six feet of loose sandy silt. Underlying the silt, the borings encountered medium dense to dense sands with occasional loose pockets to an explored depth of 104 feet. A layer six to seven feet thick of stiff silt with some organics was found at a depth of about 75 feet.

4.9 Burlington Northern Railroad Overpasses (Figure 9 and 19) 167/127 W/

These SR 167 bridges overcross three railroad tracks which run in a north-south direction. The railroad right-of-way is located between 84th Avenue South and 76th Avenue South in Kent. The overpasses are aligned northeast-southwest, about 45 degrees off the railroad alignment. Each overpass provides two traffic lanes without shoulders.

We understand from drawings provided to us that both bridges have abutment piers and two interior piers, all supported on piles. By a drawing revision, timber piles were replaced with 40-ton cast-in-place concrete piles. Half the abutment piles are battered. There are no batter piles supporting the interior pier footings.

Most of the piles were driven to tip elevations in the range of -17 to -23. Piles typically drove to capacities well in excess of 40 tons.

Planned construction of HOV lanes for SR 167 will necessitate widening the overpasses. The widening will take place within the median or the gap between the two bridges and also on the west side of the bridge for southbound traffic.

Two test borings (B-2 and B-17) were drilled in the highway median, one at each end of the overpasses. Both borings encountered approximately 35 feet of dense fill consisting of silty, gravelly sand. The fill, placed for construction of the roadway and the approach ramps leading to the overpass, is underlain by 10 to 20 feet of loose fine sand and sandy silt. This soil unit overlies loose to dense silty sand to an explored depth of 109 feet. Within this soil unit, both borings encountered a layer five to six feet thick of medium to stiff silt with some organics at a depth of 77 feet.

4.10 84th Avenue Bridges (Figures 10 and 20)

The 84th Avenue bridge overcrosses 84th Avenue South in Kent. This street is aligned north-south and the overpass alignment is approximately northeast-southwest. The overpass consists of two separate bridge structures, each providing for two traffic lanes. No shoulder is provided on either bridge.

We understand that the two existing bridge structures each have abutment piers and two interior piers, all supported on 27-ton timber piles. Half the abutment piles are battered. All of the piles were driven to tip elevations in the range of 15 to -15.

Based on plans provided to us, we understand that an HOV lane is to be constructed for both directions of traffic on SR 167. Widening of the highway at this location will take place within the existing median. The existing bridges will also be widened within this area between the bridges to construct the additional lanes.

Two test borings (B-1 and B-18) were drilled within the highway median, one at each end of the two bridges. The ground surface at both locations are approximately one to two feet below the level of the existing bridge decks. Both borings encountered about 26 feet of silty, gravelly sand fill used to construct the approach embankments for the bridges. At the northern boring the fill is loose to medium dense; the southern boring encountered generally dense fill. The fill is underlain by ten to 15 feet of loose silty, very fine sand and sandy silt. Underlying this soil unit is medium dense to dense silty sand with occasional silt layers and gravel layers, extending to the maximum explored depth of 104 feet. A layer seven to twelve feet thick of medium to stiff silt with organics was encountered within the sand at a depth of approximately 70 feet.

4.11 South 212th Street EWS Ramp (Figures 11 and 21) 167/129

This bridge crosses Springbrook Creek near the south end of the on-ramp to southbound SR 167. The SR 167 overcrossing of South 212th Street at this interchange has recently been widened. We understand that 14-inch-diameter steel pipe piles were driven to support the new pier footings.

We understand that a HOV lane is to be added to the existing EWS ramp. This will necessitate widening the existing bridge. Plans prepared by Alpha Engineers for WSDOT indicate that the bridge will be widened on the west side.

One test boring (Boring B-19) was drilled at the southwest corner of the bridge within the planned HOV lane. In general, the boring encountered approximately one foot of gravelly, sand fill on the surface. The fill is underlain by soft silt to a depth of about seven feet. Underlying the silt, the boring encountered medium dense to dense silty sand with occasional silt layers. Siltstone was encountered at a depth of 59 feet. Groundwater was noted at a depth about eight feet below the surface.

5.0 DISCUSSIONS AND RECOMMENDATIONS

5.1 General

This project will widen eight pairs of existing SR 167 overcrossing bridges between SR 18 in Auburn and 84th Avenue South in Kent. An SR 167 entrance ramp at SR 18 and another at South 212th Street also will be widened. The bridge widenings will be accomplished by removing existing guardrails, lengthening the pier cross-beams, then adding new girders, deck and edge barriers. The superstructure additions will be connected to the existing bridge superstructures and supported on new pier columns and foundations.

In the project area, SR 167 is carried on embankment fills generally 20 or more feet high placed in the 1960s. The roadways and other facilities overcrossed by SR 167 are located more or less on the natural local grades.

Each existing bridge has a concrete abutment pier at each end founded within the embankment fill well above original grades. About half the abutment piers have wing walls. All abutment piers, except those at SR 18, are pile-supported. The SR 18 abutment piers are spread footings bearing on the embankment fills. Where piles were used to support abutment piers, the approach fills were predrilled and the piles driven to bearing in the natural ground beneath the fills. About half the bridges have 50 percent of their abutment piles battered downslope normal to the abutment piers; the remaining bridges have no battered abutment piles.

In addition to the abutment piers, all the bridges have one or more interior piers, all of which bear on pile-supported footings. None of the interior pier footings has batter piles.

5.2 Existing Pile Foundations

The existing bridges are supported on both timber piles and cast-in-place concrete piles. Timber piles designed for 27 or 28 tons were used on many of the bridges constructed in the mid 1960s. Drawings for the UPRR bridges, the BNRR bridges, and the North Fourth Avenue bridges were revised and cast-in-place concrete piles 13 inches in diameter substituted for timber piles. The design capacity of these piles was 40 tons. The pile shells used likely were 12.75-inch steel pipe.

In more recent times, cast-in-place concrete piles have been used, but with increased capacities. For the SR 18 bridges, a design load of 55 tons was used on 12.75-inch steel pipe piles. In addition we understand that 14-inch steel pipe piles designed for 65 tons were driven for the recently completed widening of the South 212th Street overpass of SR 167.

During our field explorations, we observed no evidence of poor performance of any of these pile foundations. To the best of our knowledge, the performance of all existing foundations has been satisfactory.

5.3 Foundations for Bridge Additions

We recommend using pile foundations to support the bridge additions at all piers where pile foundations support the existing construction. This includes all piers at all bridges except for the abutment piers at the three SR 18 bridges. These piers may be designed as conventional spread foundations proportioned for maximum bearing stresses of 6000 pounds per square foot. The bearing grades should be the same as those of the existing pier footings. To aid in controlling differential settlements, we recommend using dowels or shear keys to connect the pier extensions to the existing piers.

Based on our review of driving records and test boring logs, we conclude that the evolution of SR 167 pile foundations from 27-ton timber piles to 65-ton pipe piles probably reflects designer and contractor preferences rather than any significant differences in superstructure loads or subsurface conditions. At current prices, steel pipe piles probably are slightly more costly on a dollar-per-ton basis than timber piles. However, it appears from the pile driving records that pile lengths generally have not been predictable, even where indicator piles were driven. In such cases, it is convenient to install piles that can be spliced easily. Steel piles or concrete piles cast in steel shells are well suited for such conditions.

Consequently, we recommend using cast-in-place concrete piles with steel shells for all pile-supported piers. For steel shells, we recommend either 12.75-inch pipe or 14-inch pipe. Either pile should conform with the requirements of WSDOT Standard Specifications section 6-05.3(4)A. The smaller pile may be designed for allowable loads up to 55 tons and the larger for allowable loads up to 70 tons. The allowable loads apply when dead and live loads are considered. When transient wind or seismic loads are included, a one-third increase in the allowable load is permissible.

Pile wall thicknesses should be based on anticipated driving stresses and may be selected by the contractor.

We estimate that 55-ton piles and 70-ton piles would reach capacity at similar tip elevations. Consequently, the pile selected should be the one that will carry the pier loads with the least unused capacity. All piles should be installed in accordance with the WSDOT Standard Specifications.

5.4 Pile Lengths

Table A summarizes for each pier of the 20 project bridges the pile tip elevations we recommend for estimating the lengths of compression piles. In general, we recommend driving the new piles to tip elevations comparable to the tip elevations of piles near the pier footing edge closest to the new construction. For some piers, the recommended tip elevations are lower than the tips of nearby existing piles. These are cases where the existing pile tips, in our judgment, are higher than would be expected, based on the boring logs.

In selecting the tip elevations in Table A, we have considered the driving records of the existing piles and the available test boring logs. It should be noted that piles supporting the present bridges vary significantly in length, even when comparing piles in the same clusters. Similar variations should be anticipated during construction of the new bridges. Moreover, we expect that variations in pile lengths may increase with pile capacity. Consequently, the high capacity piles recommended may occasionally drive through soils that stopped the lower capacity piles driven in the past. We recommend driving test piles, especially in those cases where pile capacities will be higher than the capacities of the existing piles. If the test piles drive significantly longer than expected, the possible cost advantages of reducing the allowable pile capacity should be considered.

5.5 Tension Piles

Our recommendations for estimating allowable pile tension loads are summarized on Table B. The tabulated elevations at the top of the bearing stratum (Elev. B) are based on available boring logs. For the abutment piers, the borings reported herein were considered. For the interior pier locations, which were not explored in this study, borings from WSDOT files (see Appendix C) were used. The estimated depths to the bearing stratum account for near-surface soils that may be susceptible to liquefaction during the recommended design earthquake. However, Table B does not account for possible reductions of effective stress within the bearing stratum that might occur if the overburden soils liquefied.

Because previous pile driving at the interior piers may have densified loose soils above the bearing stratum, the top-of-bearing-stratum values (Elev. B) in Table B may have been selected conservatively. At the abutment piers, the embankment fills will contribute tension capacity in addition to that calculated by Table B, provided the embankments remain stable during the design earthquake. The stability of the embankments has not been considered in this study.

Depending on the tension capacity required, compression piles used to support tension loads may have to be driven to tip elevations lower than those tabulated on Table A for compression piles.

5.6 Predrilling

For the abutment piles, predrilling may be useful in order to ease hard driving through the embankment fills. For the interior piers, predrilling likely will not be needed. We recommend leaving predrilling to the discretion of the contractor. In any case, predrilling should not extend below the top of the bearing stratum tabulated in Table B.

5.7 Foundation Settlements

For the recommended pile loads, settlements likely will not exceed one-quarter to one-half inch, plus the elastic compression of the piles. Much of this settlement will occur after the cross-beam extensions have been connected to the existing structure. Settlement subsequent to this will transfer a portion of the new superstructure load onto the existing structure. This is beneficial to the extent that it will reduce differential settlements. Connections between the new and the existing cross-beams and deck should take this expected load transfer into account.

As discussed in Section 5.12 below, pile settlements slightly larger than noted above may occur where fills will be placed to widen the existing embankments.

5.8 Pile Spacing

The spacing among piles in clusters should be at least three pile diameters, measured center-to-center. Piles at this spacing or greater can be used at their recommended capacities without reduction for cluster effects.

5.9 Alternative Deep Foundations

Driven piles may be undesirable in cases where the ground vibrations from driving might annoy occupants of nearby buildings, or where space is not available to construct a large pile cap. We have not identified any project areas where we believe either of these factors should control foundation selections. Nevertheless, alternatives to the driven piles recommended may be considered.

Vibrations could be virtually eliminated by using a pile cast in an augered hole rather than in a driven steel shell. Augercast piles satisfy this condition. In our opinion, augercast piles, which would have to be reinforced, are not appropriate for the battered piles that likely will be needed to support the large lateral loads carried by the bridge piers. Consequently, we do not recommend augercast piles for alleviating vibration problems.

Large-diameter drilled shafts could be considered as an alternative to driven piles, provided that plumb shafts are adequate to carry the lateral loads. To our knowledge, single drilled shafts have not been used in the Kent Valley alluvium to support heavy bridge loads. Because of the groundwater conditions in the valley, the drillholes would need support prior to placing the shaft concrete. Steel casing could be used with the hole kept full of water, or drilling mud could be used and the casing eliminated. In either case, it would be difficult to verify bearing conditions at the bottom of the hole prior to placing the concrete. For such working conditions, we recommend drilling every intended shaft location prior to completing a final design. If requested, we will be pleased to assist you with conducting the additional explorations and soil testing and providing the needed design parameters.

Preliminary calculations to assess the feasibility of large-diameter drilled shafts for carrying the vertical pier loads may be made using the information presented on Table B. The shafts should bear below the Elevs. B on Table B. In order for the shafts to transfer lateral pier loads to the bearing stratum below Elev. B, the shafts will need to be embedded into the bearing stratum below Elev. B, probably four shaft diameters or more.

The allowable vertical load capacity of a shaft consists of a bearing stress on the base of the shaft, plus a shear stress on the circumference of the shaft. The allowable bearing stress on the base of shafts may be estimated as ten times the effective stress at the bearing elevation, but not more than 15 tons per square foot. Effective stresses may be estimated using the dimensions given in Table B and the unit weights shown on the diagram at the bottom of the table.

In addition, a shear stress will act on the circumference of the shaft below Elev. B. The shear stress per unit area may be estimated as 0.2 times the effective stress calculated as described above.

5.10 Seismic Considerations

We understand that the current WSDOT design earthquake is intended to have a 90 percent probability of non-occurrence in 50 years. This corresponds closely with an estimated return period of 500 years. In the project vicinity, events with this low occurrence frequency currently are estimated to have magnitude 7.5 on the Richter scale. Predicted horizontal accelerations are in the range of 0.25g.

In our opinion, loose near-surface sands below the water table at all of these sites may liquefy during an event as severe as the 7.5-magnitude design earthquake. Since foundation piles would be driven through all soils with significant liquefaction potential, liquefaction likely would not impair the vertical load capacity of foundations. However, liquefaction may adversely affect lateral load capacity and cause differential settlements of the ground surface.

5.11 Lateral Loads

All the test borings encountered significant thicknesses of loose to medium dense, clean to silty sands below the water table. These materials have a high potential for liquefaction during intense seismic events. The top-of-bearing-stratum values (Elev. B) in Table B are our estimate of the maximum depths that liquefaction might occur during the design earthquake. Much, but not all, the soil above these elevations is expected to liquefy. In our opinion, soil that may liquefy during the design earthquake should be expected to have little or no resistance to lateral loads. This greatly complicates the problem of finding suitable lateral load reactions. Vertical piles likely will be able to carry only a small portion of the lateral loads.

The lateral load capacities of vertical piles or shafts may be estimated by reference to the diagram at the bottom of Table B. Significant lateral load resistance will be available only below Elev. B. For estimating p-y curves, the soils may be assumed to be sands. Appropriate unit weights are shown on the diagram. The friction angle below Elev. B may be taken as 40 degrees for driven piles and 37 degrees for drilled shafts. Above Elev. B, we recommend using a friction angle of five degrees to account for the small residual strength some of these soils may have near the end of the seismic shaking. The initial slope of the p-y curves can be estimated using a "k" of 100 pounds per cubic inch below Elev. B and 3 pounds per cubic inch above Elev. B.

Several alternatives to vertical piles or shafts for providing lateral load reactions should be considered. At abutment piers, the use of spread foundations similar to those used at the SR 18 bridges may be practical, provided the approach embankments are expected to be stable during the design earthquake. The stability of approach embankments has not been considered in this study. If spread foundations are used at such locations, they may be designed to support lateral loads up to 35 percent of their vertical load.

At all piers where plumb piles are not adequate to carry the lateral loads, batter piles may be used. Batter piles should not be out of plumb more than 3 vertical to 1 horizontal. Where batter piles are used, in order to reduce the risk of damage to existing bridges and their foundations, care should be taken when considering the locations and batter directions of new piles.

It appears, based on preliminary calculations, that large-diameter drilled shafts might be stiff enough to transfer the anticipated lateral loads to the bearing stratum below the Elevs. B on Table B. Such shafts likely would have diameters in the range of six to ten feet and embedment into the bearing stratum below the Elevs. B in the range of five shaft diameters.

The use of vibroflotation to densify the loose, potentially liquefiable near-surface soils provides another possible alternative to batter piles. If the area vibrofloted around the pier was large enough, the use of spread foundations could be considered. Alternatively, after the area around a pier was treated by vibroflotation, plumb piles could carry a substantial portion of the lateral loads.

The test borings completed in the present study have explored the abutment areas, but not the interior pier areas where the liquefaction risk may be higher. In our opinion, the explorations completed justify only a recommendation for driven piles similar to those that have previously been used successfully at these locations. Consequently, we recommend use of driven piles, including batter piles as needed to carry the lateral loads. If further considerations indicate that any of the alternatives discussed above may be an attractive substitute for batter piles, we recommend selecting a specific area for study, then performing additional explorations and laboratory testing.

5.12 Downdrag from Embankment Widenings

We understand from cross-sections provided us by the Alpha Engineering Group that the SR 167 embankments must be widened at the Meeker Street and the BNRR overcrossings in order to accommodate new ramps. The weight of these new fills will not significantly compress the existing embankment fills, which generally are well compacted, but will compress the loose native soils above the Elevs. B on Table B. Much of this compression will occur fairly rapidly, but not instantaneously. If the new piles are installed before these soils complete their compression, both the compressing layer and the overlying embankment will move downward with respect to the piles. In that case, friction on the pile sides will act downward, tending to pull the piles into the ground.

At Meeker Street, the cross-sections indicate new fill depths in the range of six to seven feet at both sides of the south abutment. At the north abutment, there will be new fills about seven feet deep on the east side and virtually nothing on the west side. At the BNRR overcrossing, there will be new fills only about four feet deep on the west side at the south abutment, about six feet deep on the east side at the north abutment, and nine feet deep on the west side at the north abutment.

We have made settlement estimates based on the consolidation tests reported in Appendix B and reviewed settlement records from building sites in the Kent Valley where fill depths have been placed comparable to the depths of the ramp fills described above. We conclude that settlements near the bridge abutments that the ramp fills may cause are not likely to exceed one-half inch after the time the piles are installed.

This relatively small estimated settlement is a consequence of three factors: 1) the abutment piles will be installed near a corner of the ramp fills, which will reduce the influence the fill weight will have on the underlying compressible soils; 2) the weight of the existing embankment has increased the stress on the compressing soils and reduced their compressibility; and 3) because the consolidation time for the compressing soils likely will not exceed several weeks, much of the compression will occur before the piles are installed.

The potential downdrag load on the piles cannot be calculated accurately. For piles 13 to 14 inches in diameter, we estimate that downdrag loads could be in the range of 20 to 30 tons. Because the piles, once filled with concrete, will not fail in compression, and because the maximum pile settlement due to the downdrag cannot exceed the maximum expected embankment settlement of one-half inch, the downdrag, in our opinion, does not need to be included in the pile loads. In our judgment, pile performance will not be significantly affected if the downdrag-induced settlements do not exceed one-half inch.

In order to verify during construction that embankment and abutment settlements induced by the ramp fills are indeed small, we recommend the following:

1) Monitor the elevation near the edge of the existing abutments adjacent the ramp fill; and

2) Install settlement markers on the embankment slopes beneath the outside edge of the abutment additions and monitor settlements as the ramp fills are placed.

If the settlement rates at the markers indicate that settlements after the piles are driven are not likely to exceed one-half inch, predrill through the embankment fills and install the contract piles. If excessive settlements are observed at the markers, consider using one of the following methods for reducing the potential downdrag:

1) Delay pile driving until the settlements decrease.

2) Predrill an oversized hole to the bottom of the embankment fills, or deeper to the top of the bearing stratum, and coat the pile above the bearing stratum with bitumen.

3) Predrill with hollow-stem augers and backfill the borehole with drilling mud as the augers are withdrawn. Drive a bitumen-coated pile.

Any of these corrective measures should be considered contract extras to be employed only as directed by WSDOT.

6.0 LIMITATIONS

The analyses and recommendations submitted herein are based on data obtained from test borings and on observations of nearby structures. However, subsurface conditions at locations not explored may differ from those observed in the test borings. The nature and extent of any such variations may not become evident until construction.

This report has been prepared specifically for this project. It is the property of Terra Associates, Inc. and is intended for the exclusive use of the Alpha Engineering Group, WSDOT and their representatives. We do not guarantee project performance in any respect, only that our work meets normal standards of professional care. No other warranty, expressed or implied, is provided.

TABLE A
RECOMMENDATIONS FOR COMPRESSION PILES
SR 167 Overpass Bridges
15th Street SW To South Grady Way
King County, Washington

Bridge No. & Name	Existing Foundations				New Foundations Recommendations		
	Pier	Type	Capacity	Pile Tip Elev.	Dead & Live Loads (tons)	Capacity	Estimated Tip Elevs.
167/112E	1	F	3tsf		219		
	2	P	55 ton	43, 49, 50	459		25
	3	P	55 ton	37, 39, 34	528	55/70 tons	25
SR18	4	P	55 ton	22,25, 24	473		25
	5	P	55 ton	-45, -44, 32	379		25
	6	F	3 tsf		211		
167/112W	1	F	3 tsf				
	2	P	55 ton	42, 43, 44			25
	3	P	55 ton	16, 40, 17			20
SR18	4	P	55 ton	38, 40, 41, 41, 41	unknown	55/70 tons	25
	5	P	55 ton	5, 5, -44, 4, 4			5
	6	F	3tsf				
167/112	1	F	3 tsf		219		
EWN	2	P	55 ton	43, 45, 48, 45, 46	503		35
	3	P	55 ton	-47, -46, -45, -46, 28	606	55/70 tons	25
SR18	4	P	55 ton	27, 27, 32, 32, 33	542		25
Ramp	5	P	55 ton	39, 49, 46, 50, 38	432		35
	6	F	3 tsf		219		
167/121E	1	T	27 ton	-4, -6	144		-10
	2	T	27 ton	7@-9 to -20	990		-30
Green	3	T	27 ton	7@-12 to -27	990	55/70 tons	-30
River	4	T	27 ton	-2, 9	144		-10
167/121W	1	T	27 ton	-12, -10	144		-10
	2	T	27 ton	7@-10 to -32	990		-30
Green	3	T	27 ton	7@-12 to -21	990	55/70 tons	-30
River	4	T	27 ton	-3, -8	144		-10
167/122E	1	T	28 ton	-1, 1	303		0
	2	T	28 ton	-5, -1, -6, -5	535	55/70 ton	-5
SR516	3	T	28 ton	2,1	308		0
167/122W	1	T	28 ton	5, 5	303		5
	2	T	28 ton	-5, -5, -4, -5	535	55/70 ton	-5
SR516	3	T	28 ton	7, 4	308		5

TABLE A
(Continued)

Bridge No. & Name	Existing Foundations: Pier	Type	Capacity	Pile Tip Elev.	New Foundations Recommendations: Dead & Live Loads (tons)	Capacity	Estimated Tip Elevs.
167/123E	1E	T	27 ton	2, 0	393		0
	1W	T	27 ton	-1, 4	193		0
	2E	T	27 ton	-17, -17, -15	615		-15
	2W	T	27 ton	-8, -6, -6	316	55/70 tons	-10
Meeker St	3E	T	27 ton	1, -4, -2	587		-5
	3W	T	27 ton	-6, -8, -7	316		-10
	4E	T	27 ton	11, 11	292		10
	4W	T	27 ton	5, 10	193		10
167/123W	1E	T	27 ton	-10, -4	193		-5
	1W	T	27 ton	-3, -4	192		-5
	2E	T	27 ton	-9, -10, 1	316		-10
	2W	T	27 ton	-10, -2, -2	278	55/70 tons	-10
Meeker St	3E	T	27 ton	11, 10, 1	316		-10
	3W	T	27 ton	-1, -3, -3	210		-5
	4E	T	27 ton	7, 7	193		10
	4W	T	27 ton	-5, -5	93		-5
167/124E	1	T	27 ton	1, 3	253		0
	2	T	27 ton	6, 6, 3, -5	407	55/70 tons	0
James St	3	T	27 ton	4, 5, 6, 4	415		0
	4	T	27 ton	5, 2	262		0
167/124W	1	T	27 ton	1, 3	253		0
	2	T	27 ton	6, -3, -4, 5	407		-10
James St	3	T	27 ton	-12, -10, -7, -8	415	55/70 tons	-10
	4	T	27 ton	8, 4	262		0
167/125E	1	P	40 ton	4, 5	548		0
	2	P	40 ton	-21, -21, -21, -22	1256	55/70 tons	-20
UPRR	3	P	40 ton	-19, -19, -19, -19	1229		-20
	4	P	40 ton	4, 4	527		0
167/125W	1	P	40 ton	4, 5	550		0
	2	P	40 ton	-22, -21, -21, -21	1246		-20
UPRR	3	P	40 ton	-18, -18, -18, -18	1247	55/70 tons	-20
	4	P	40 ton	3, 8, 3, 5, 3	561		0
167/126E	1	P	40 ton	-27, -27	330		-30
	2	P	40 ton	7@-27 to -33	482		-30
4th Ave	3	P	40 ton	7@-24 to -26	482	55/70 tons	-30
	4	P	40 ton	-24, -27	330		-30
167/126W	1	P	40 ton	-28, -26	330		-30
	2	P	40 ton	7@-26 to -30	482		-30
4th Ave	3	P	40 ton	7@-26 to -27	482	55/70 tons	-30
	4	P	40 ton	-25, -25	330		-30

TABLE A
(Continued)

Bridge No. & Name	Existing Foundations				New Foundations Recommendations		
	Pier	Type	Capacity	Pile Tip Elev.	Dead & Live Loads (tons)	Capacity	Estimated Tip Elevs.
67/127E	1	P	40 ton	-16, 23	422		-15
	2	P	40 ton	-19, -20, -21	805		-20
BNRR	3	P	40 ton	-20, -18, -18	805	55/70 tons	-20
	4	P	40 ton	6, -4	422		0
167/127W	1E	P	40 ton	-21, -22	422		-20
	1W	P	40 ton	-21, -23	214		-20
	2E	P	40 ton	-17, -17, -18	805		-20
	2W	P	40 ton	-19, -17, -17	465		-20
BNRR	3E	P	40 ton	-20, -20, -20	805	55/70 tons	-20
	3W	P	40 ton	-19, -18, -19	521		-20
	4E	P	40 ton	6, 3	422		0
	4W	P	40 ton	3, 2	296		0
167/128E	1	T	27 ton	0, -1	271		-5
	2	T	27 ton	-5, -6, -6, -2	491		-10
84th Ave	3	T	27 ton	-2, -3, -2, -2	484	55/70 tons	-10
	4	T	27 ton	17, 11	263		5
167/128W	1	T	27 ton	4, -1	275		5
	2	T	27 ton	no data	491	55/70 tons	-10
84th Ave	3	T	27 ton	6, 2, 5, 5	484		-10
	4	T	27 ton	10, 9	263		5
167/~~130~~ 129 S 212th St	No information			--	--	55/70 tons	-25

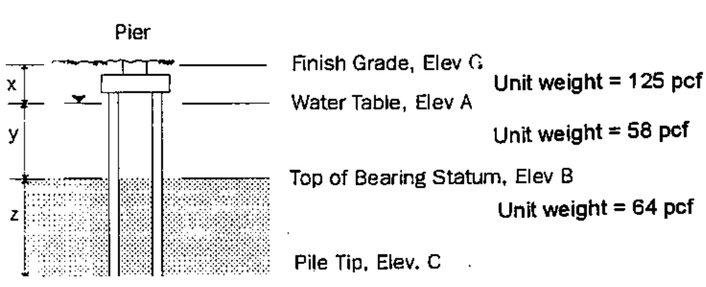
Notes 1. Tip elevations of existing piles are those at the edges of footings closest to the new footings.
2. Pile Types: P - 12-3/4 inch steel pipe
T - Timber
F - Conventional spread footing
3. Recommended capacities for new piles are for 12.75 and 14-inch tip diameters, respectively.

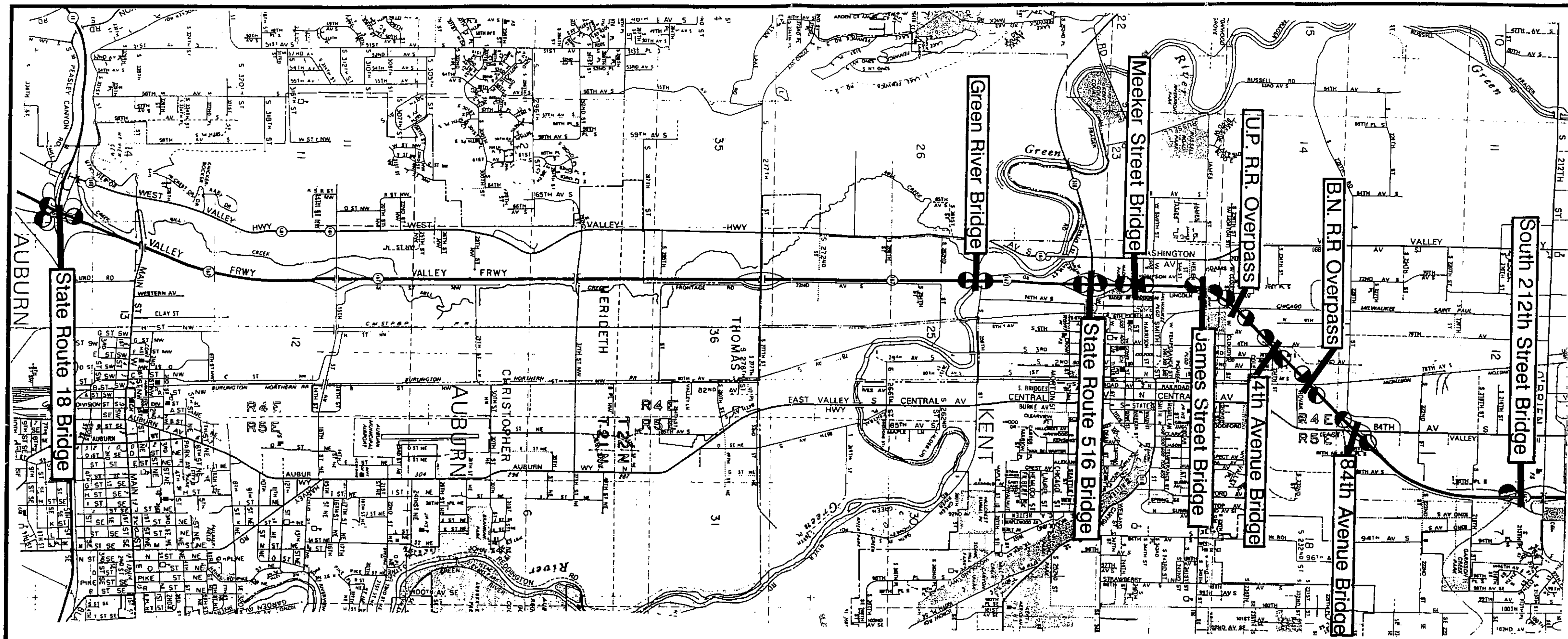
TABLE B
Recommendations for Tension Piles
SR167 Bridges
King County, Washington

Bridge	Pier	Elev. A	Elev. B	Bridge	Pier	Elev. A	Elev. B
167/112E	2	64	44	167/124W	1	28	8
SR18	3	63	45	James St.	2	28	0
	4	63	40		3	28	0
	5	62	35		4	28	9
167/112W	2	64	48	167/125E	1	25	6
SR18	3	64	52	UPRR	2	25	7
	4	63	50		3	25	3
	5	62	47		4	25	10
167/112EWN	2	64	46	167/125W	1	25	6
SR18 Ramp	3	63	48	UPRR	2	25	5
	4	63	48		3	25	1
	5	62	48		4	25	10
167/121E	1	30	16	167/126E	1	26	0
Green River	2	30	14	4th Ave.	2	26	-4
	3	30	14		3	26	4
	4	30	16		4	26	10
167/121W	1	30	16	167/126W	1	26	0
Green River	2	30	14	4th Ave.	2	26	0
	3	30	14		3	26	4
	4	30	16		4	26	10
167/122E	1	34	10	167/127E	1	26	3
SR516	2	34	10	BNRR	2	26	-4
	3	34	10		3	26	4
					4	26	10
167/122W	1	34	10	167/127W	1	26	3
SR516	2	34	10	BNRR	2	26	0
	3	34	10		3	26	-3
					4	26	10
167/123E	1	28	8	167/128E	1	27	15
Meeker St.	2	28	7	84th Ave.	2	27	15
	3	28	5		3	27	16
	4	28	9		4	27	16
167/123W	1	28	10	167/128W	1	27	15
Meeker St.	2	28	10	84th Ave.	2	27	15
	3	28	10		3	27	16
	4	28	14		4	27	16
167/124E	1	28	8	167/130EWS	all	22	-15
James St.	2	28	7	S 212th St.			
	3	28	5	Ramp			
	4	28	9				

T=.031DZ (.12X + .058Y + .032Z)
D=Pile diameter, inches
X=Elev G - Elev A, Feet
Y=Elev A - Elev B, Feet
Z=Elev B - Elev C, Feet
T=Allowable tension load, tons

Where Elev A is above Elev G:
1) X=zero
2) Y=Elev G - Elev B, Feet





LEGEND

◐ APPROXIMATE TEST BORING LOCATION

REF: Based on Thomas Bros. Maps, 1989 Edition.

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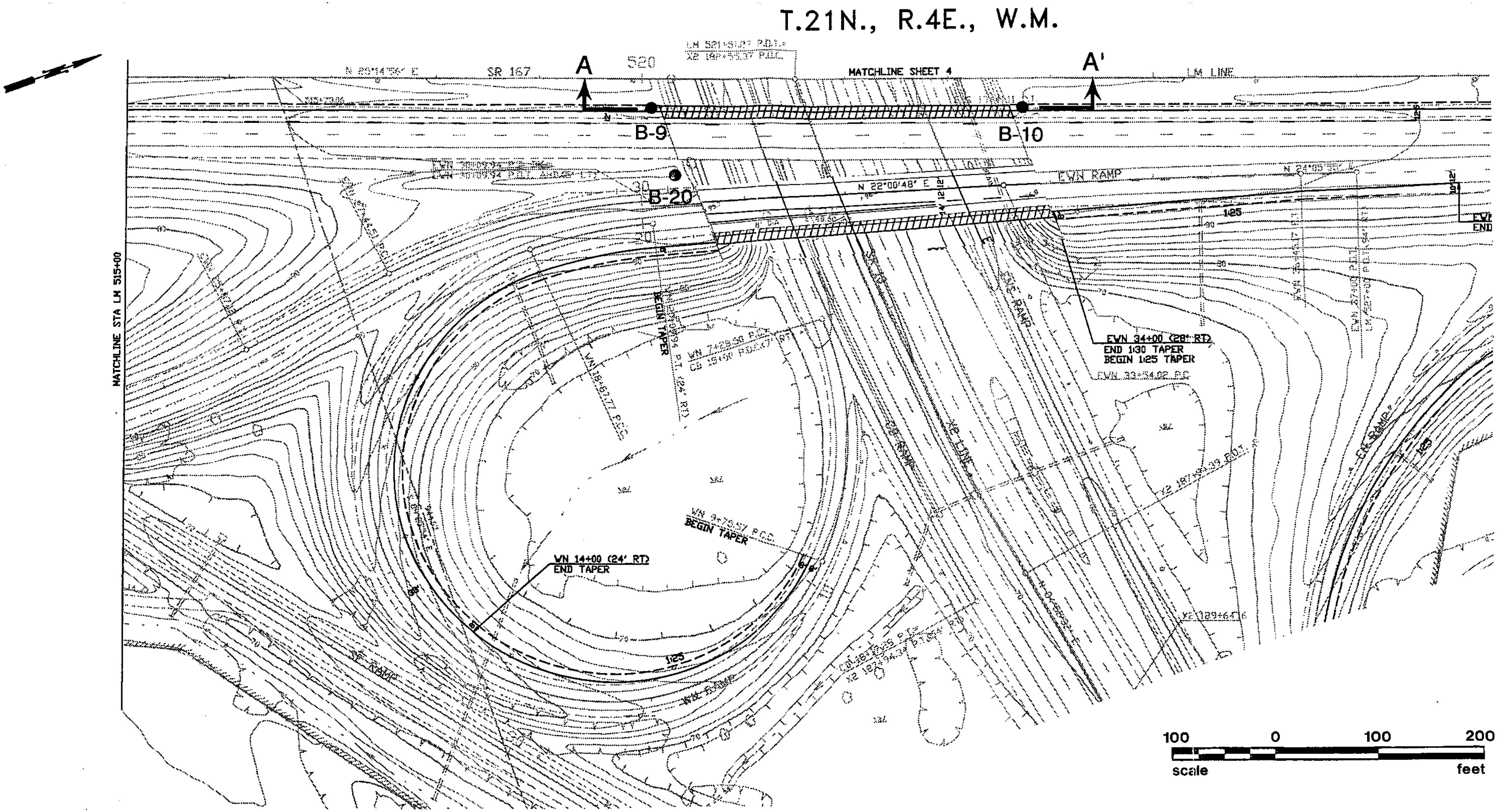
VICINITY MAP

STATE ROUTE 167

Proj. No. 1630	Date 10-91	Figure 1



LEGEND

● B-1 APPROXIMATE TEST BORING LOCATION

REF: Based on WSDOT SR-167, 15th Street SW to South Grady Way Alternative Analysis.

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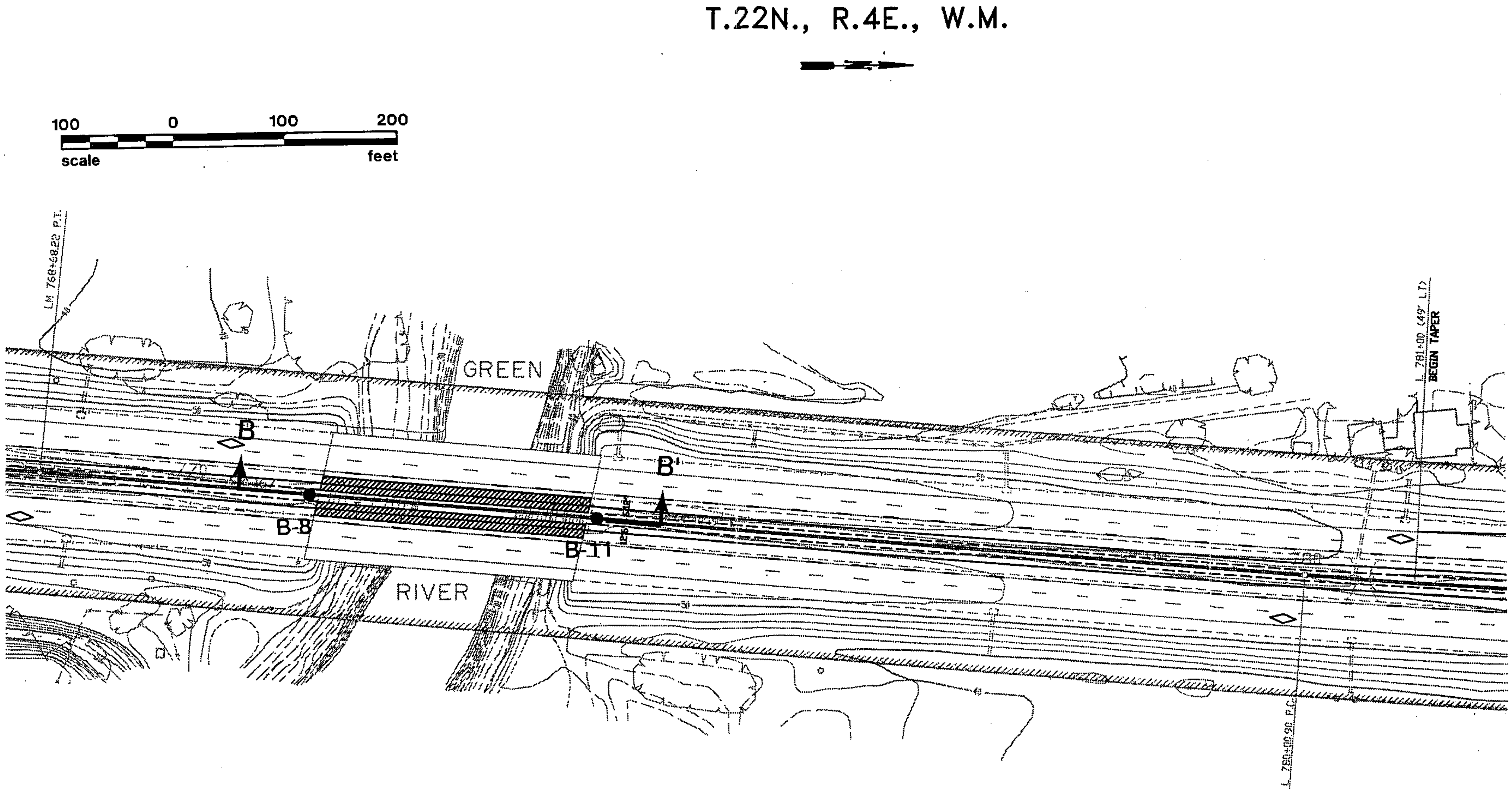
Geotechnical Consultants

EXPLORATION LOCATION PLAN STATE ROUTE 167 STATE ROUTE 18 BRIDGE		
Proj. No. 1630	Date 10-91	Figure 2



LEGEND

● B-1 APPROXIMATE TEST BORING LOCATION

REF: Based on WSDOT SR-167, 15th Street SW to South Grady Way Alternative Analysis.

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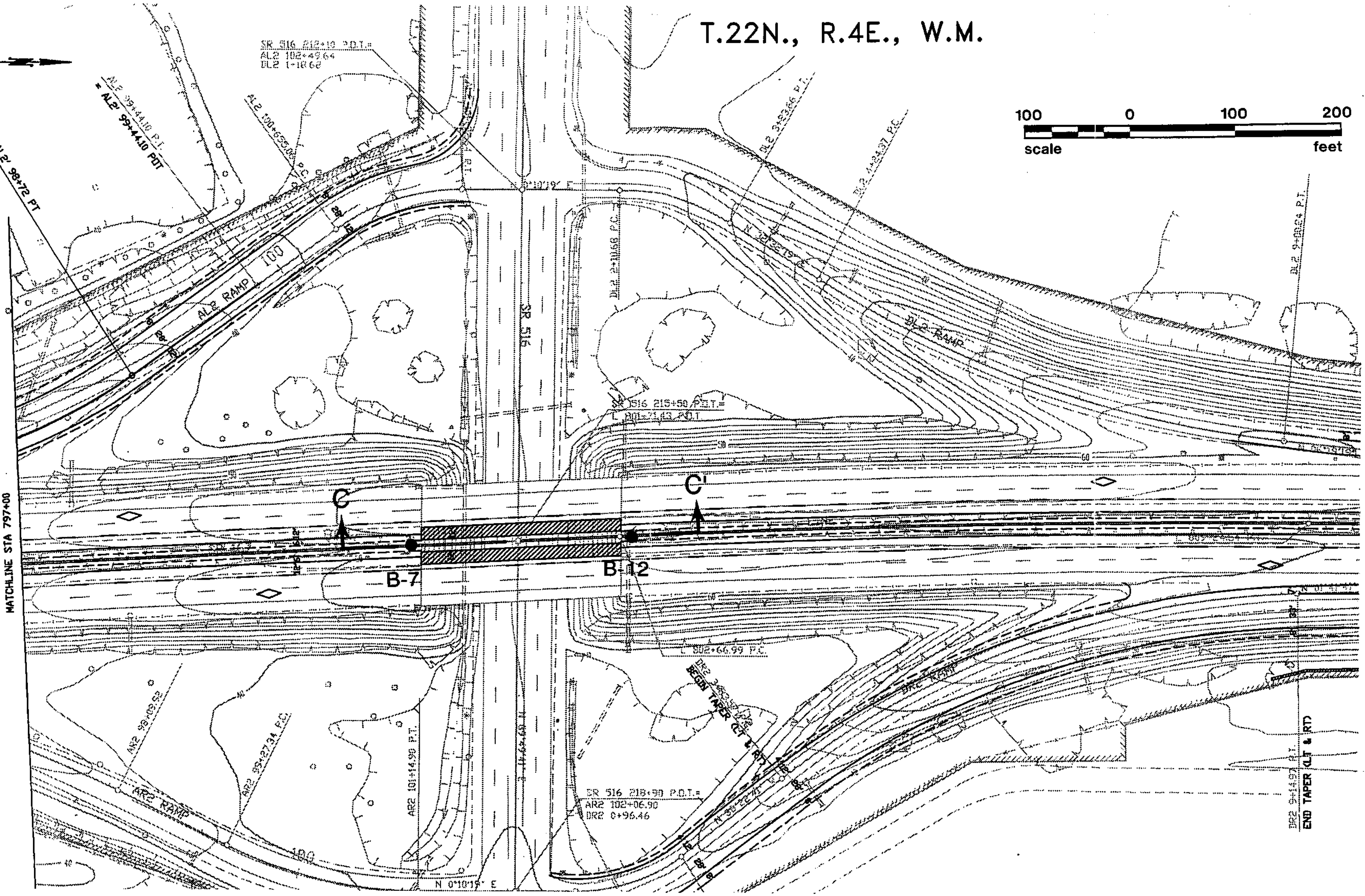
Geotechnical Consultants

EXPLORATION LOCATION PLAN STATE ROUTE 167 GREEN RIVER BRIDGE		
Proj. No. 1630	Date 10-91	Figure 3



LEGEND

● B-1 APPROXIMATE TEST BORING LOCATION

REF: Based on WSDOT SR-167, 15th Street SW to South Grady Way Alternative Analysis.

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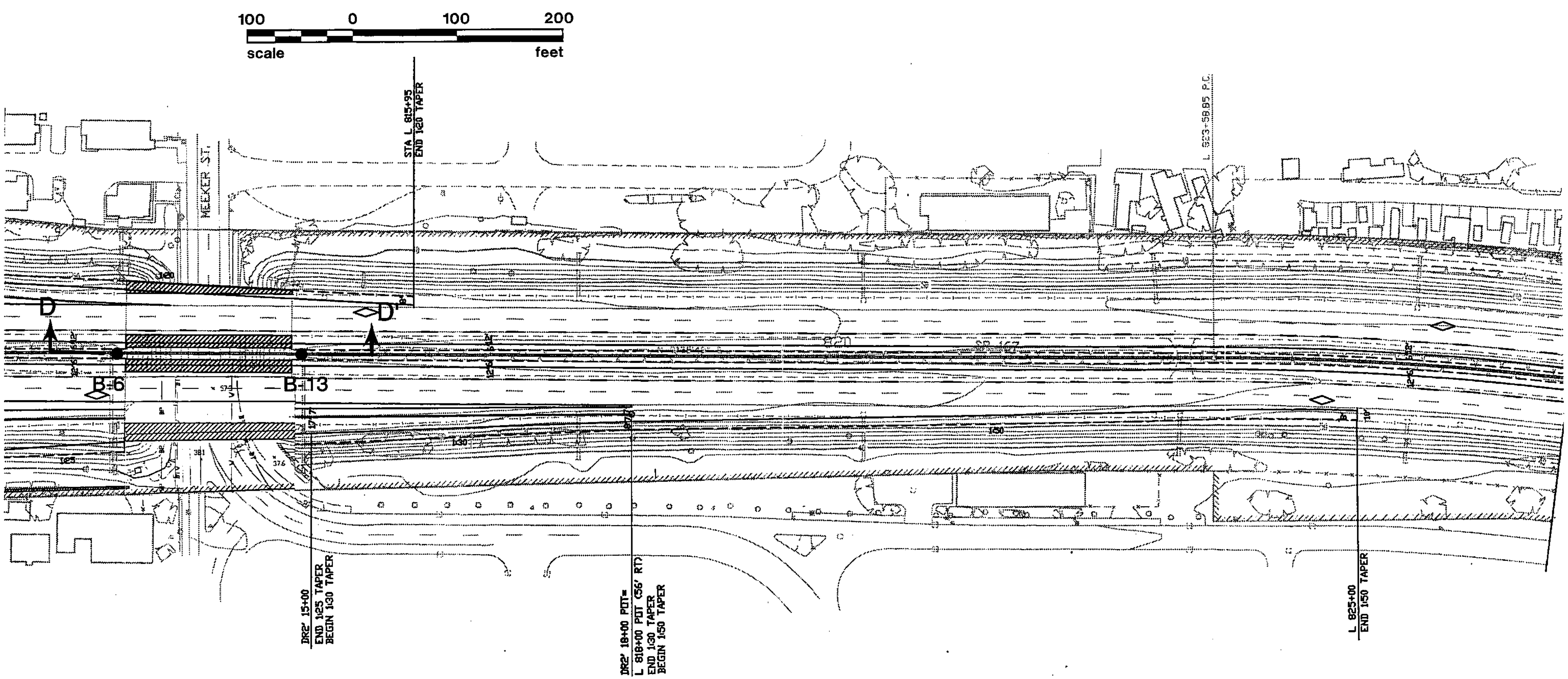
EXPLORATION LOCATION PLAN
STATE ROUTE 167
STATE ROUTE 516 BRIDGE

Proj. No. 1630	Date 10-91	Figure 4

T.22N., R.4E., W.M.



LEGEND

● B-1 APPROXIMATE TEST BORING LOCATION

REF: Based on WSDOT SR-167, 15th Street SW to South Grady Way Alternative Analysis.

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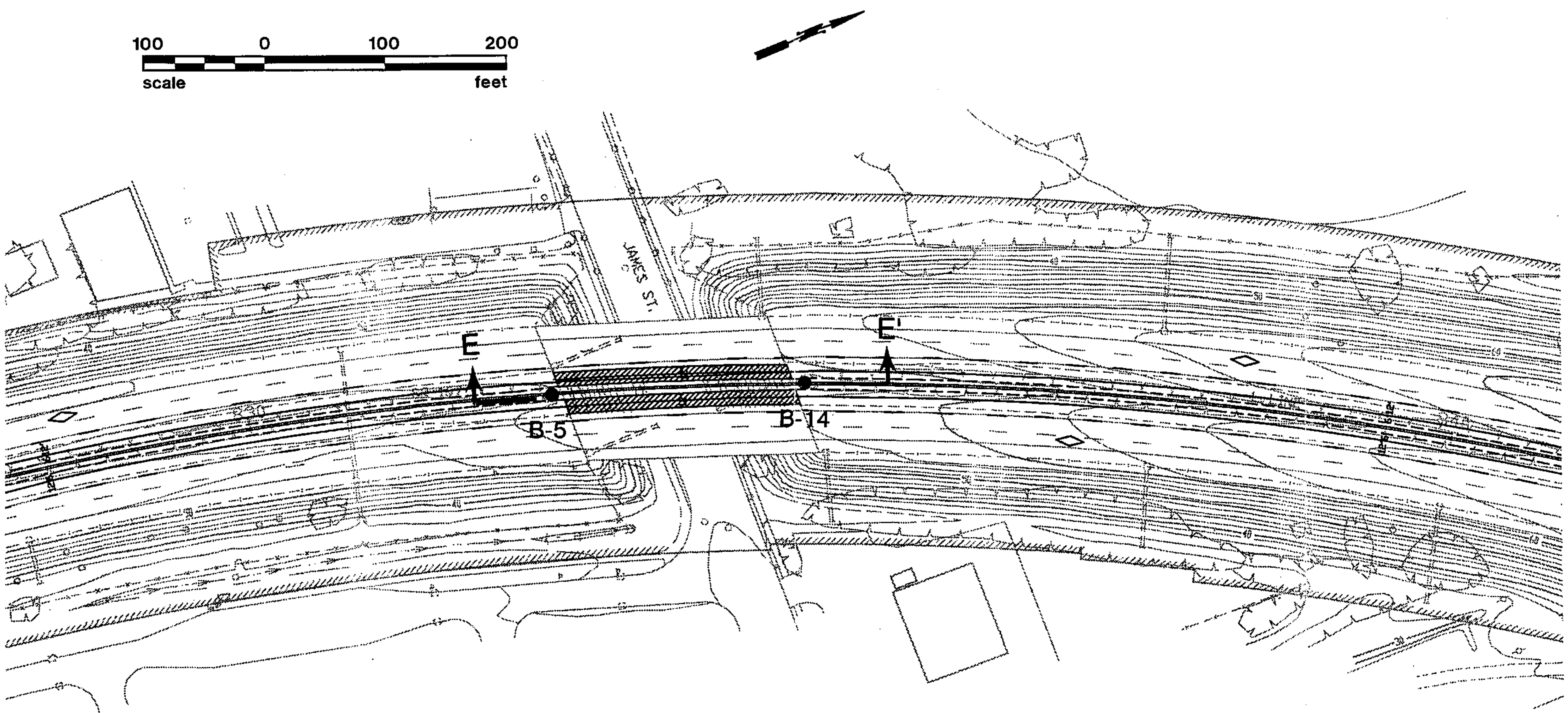
EXPLORATION LOCATION PLAN
STATE ROUTE 167
MEEKER STREET BRIDGE

Proj. No. 1630 | Date 10-91 | Figure 5

T.22N., R.4E., W.M.

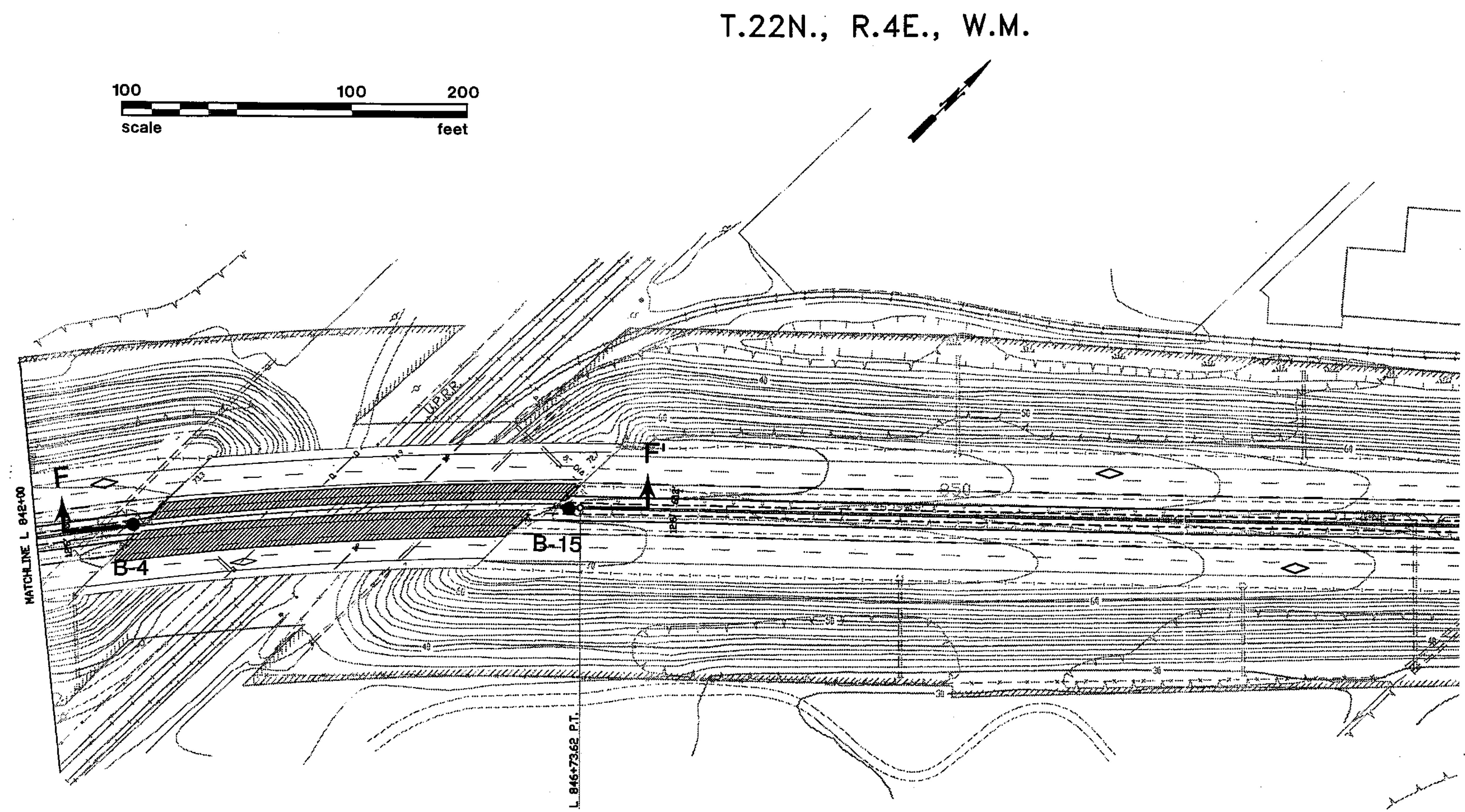


LEGEND

● B-1 APPROXIMATE TEST BORING LOCATION

REF: Based on WSDOT SR-167, 15th Street SW to South Grady Way Alternative Analysis.

TERRA ASSOCIATES Geotechnical Consultants	EXPLORATION LOCATION PLAN STATE ROUTE 167 JAMES STREET BRIDGE
Proj. No. 1630	Date 10-91
Figure 6	



LEGEND

● B-1 APPROXIMATE TEST BORING LOCATION

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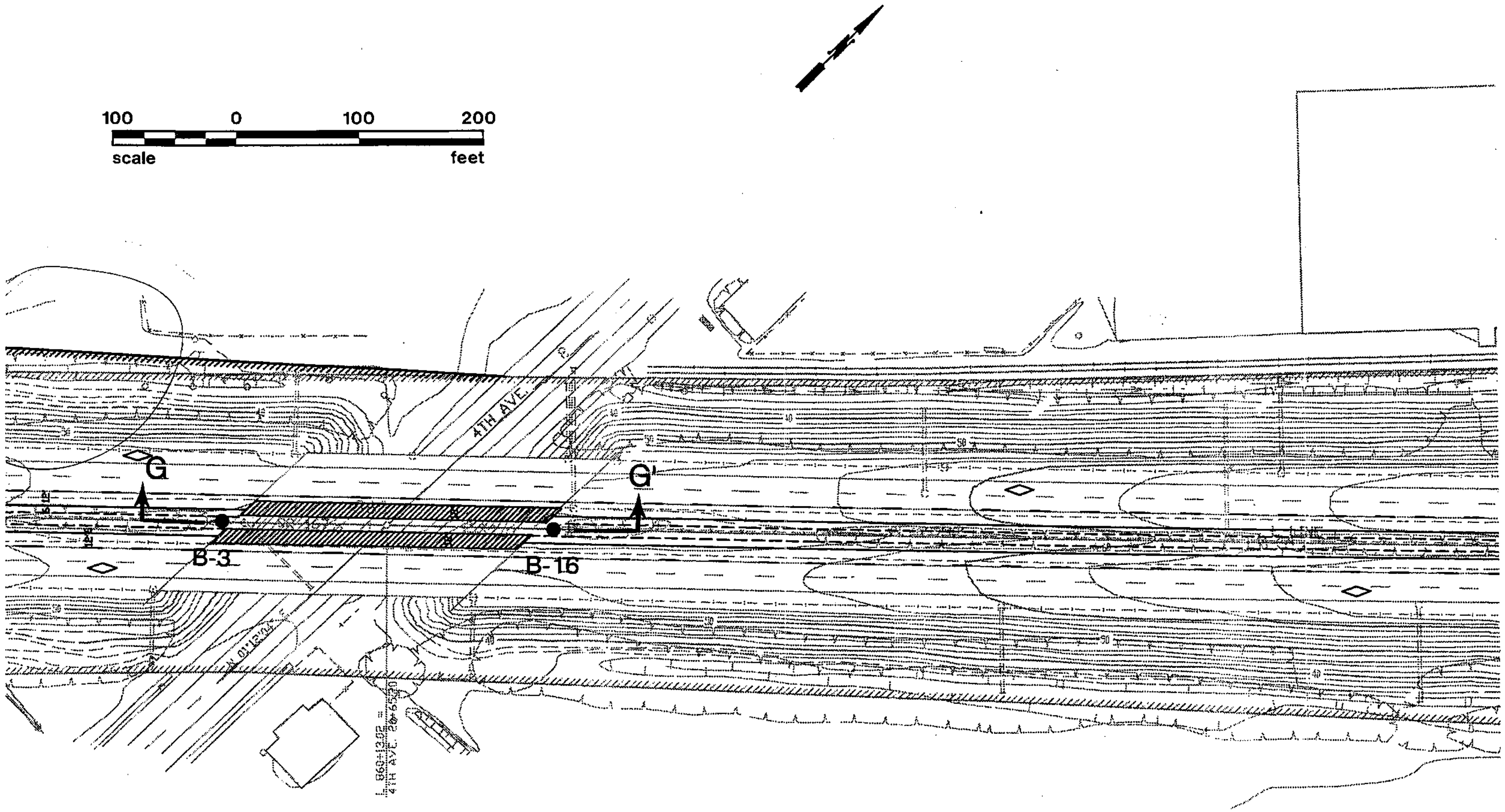
EXPLORATION LOCATION PLAN STATE ROUTE 167 U.P. R.R. OVERPASS		
Proj. No. 1630	Date 10-91	Figure 7

REF: Based on WSDOT SR-167, 15th Street SW to South Grady Way Alternative Analysis.

T.22N., R.4E., W.M.



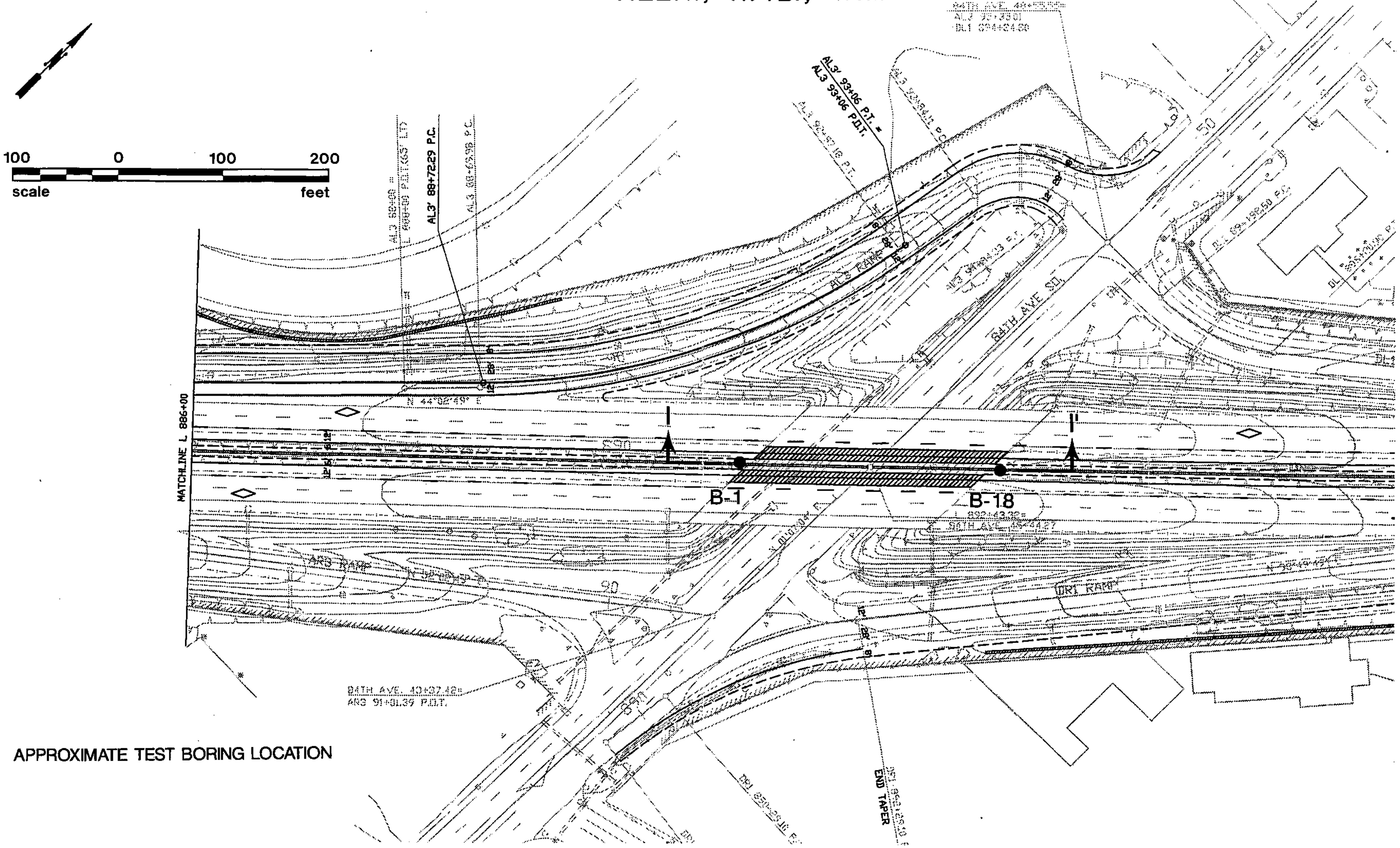
LEGEND

● B-1 APPROXIMATE TEST BORING LOCATION

REF: Based on WSDOT SR-167, 15th Street SW to South Grady Way Alternative Analysis.

TERRA ASSOCIATES Geotechnical Consultants	EXPLORATION LOCATION PLAN STATE ROUTE 167 4TH AVENUE BRIDGE		
	Proj. No. 1630	Date 10-91	Figure 8

T.22N., R.4E., W.M.



LEGEND

● B-1 APPROXIMATE TEST BORING LOCATION

REF: Based on WSDOT SR-167, 15th Street SW to South Grady Way Alternative Analysis.

TERRA ASSOCIATES
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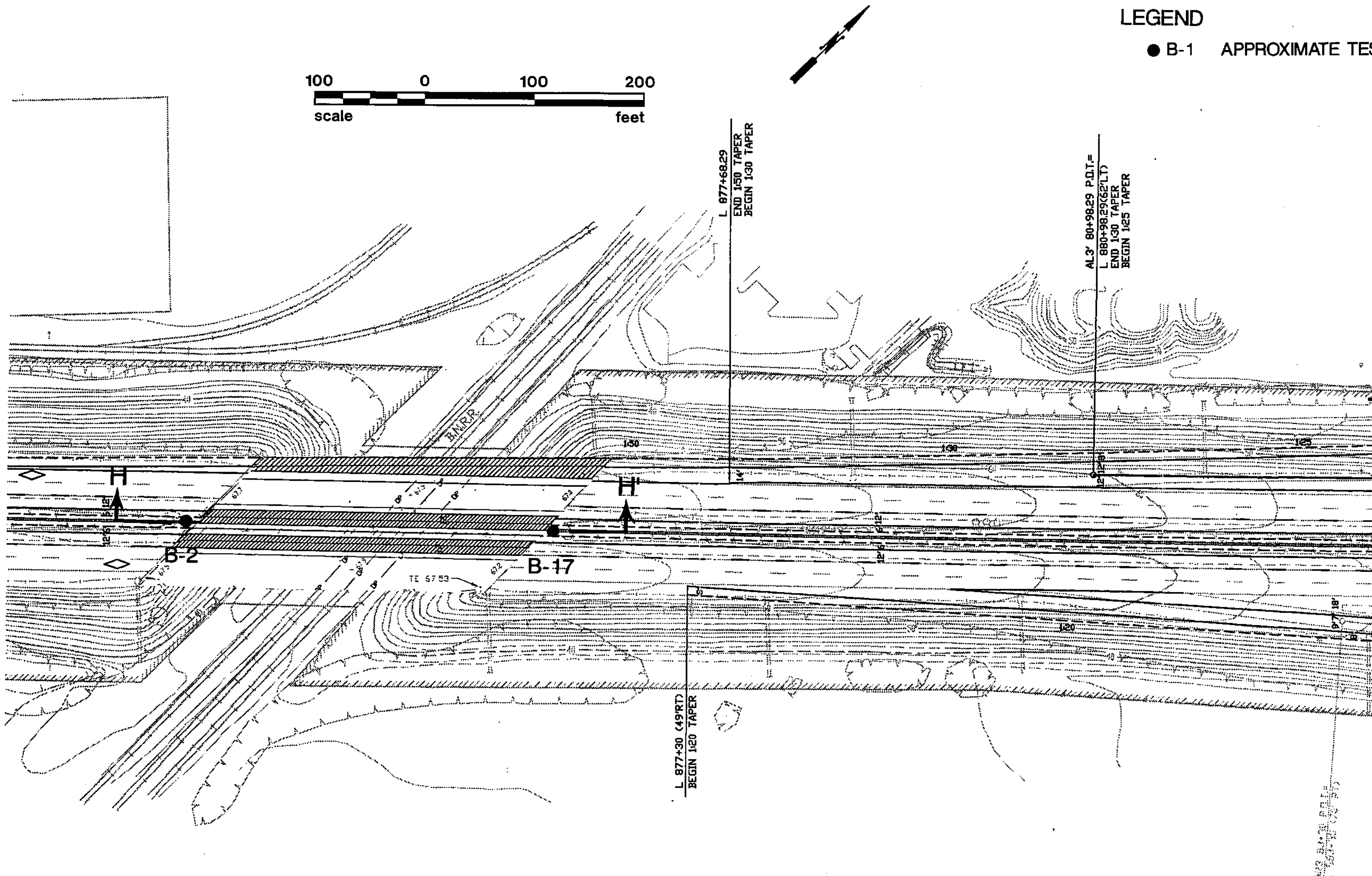
EXPLORATION LOCATION PLAN
STATE ROUTE 167
84TH AVENUE BRIDGE

Proj. No. 1630	Date 10-91	Figure 10

T.22N., R.4E., W.M.

LEGEND

● B-1 APPROXIMATE TEST BORING LOCATION



TERRA ASSOCIATES
Geotechnical Consultants

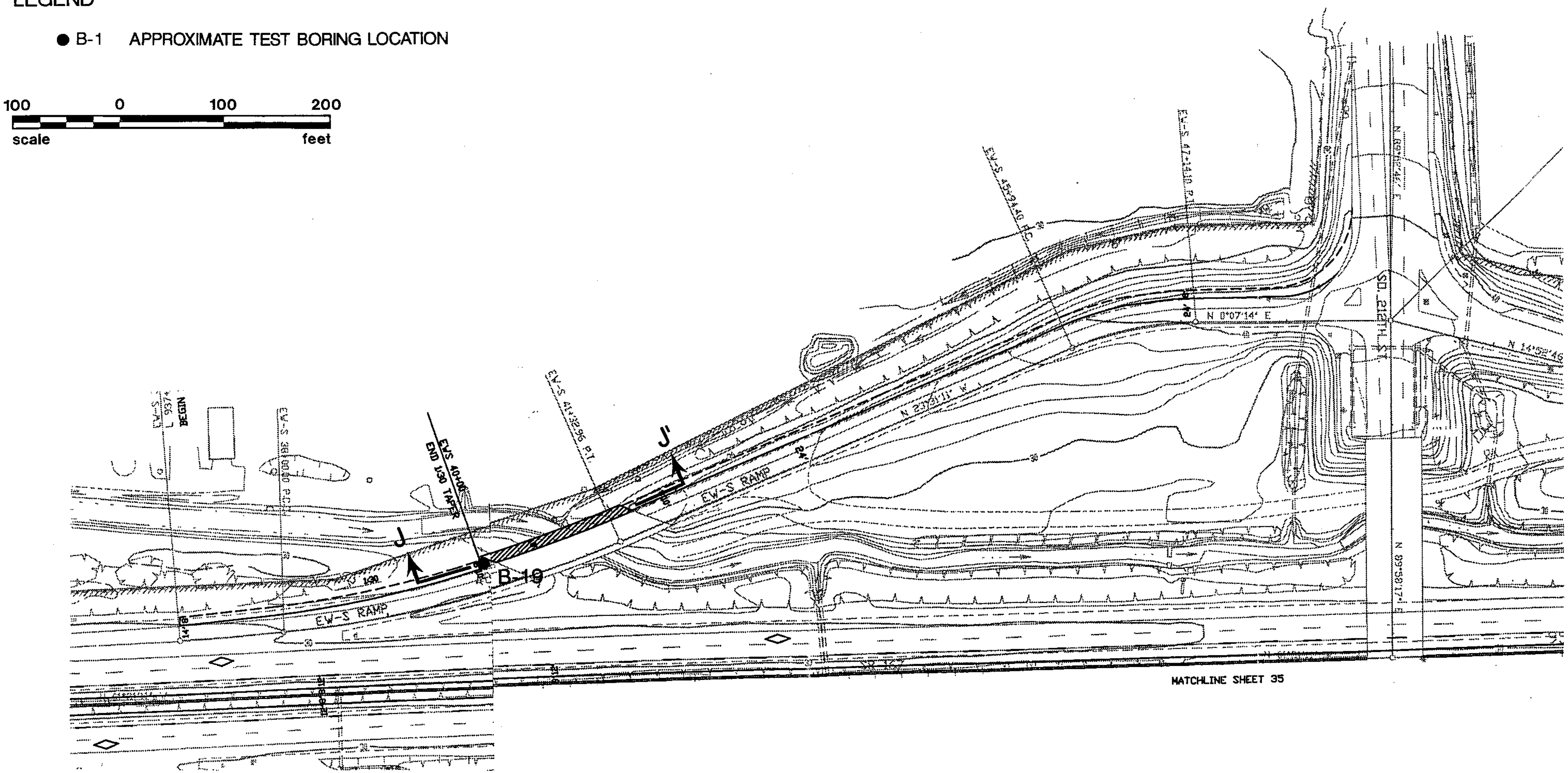
EXPLORATION LOCATION PLAN STATE ROUTE 167 B.N. R.R. OVERPASS		
Proj. No. 1630	Date 10-91	Figure 9

REF: Based on WSDOT SR-167, 15th Street SW to South Grady Way Alternative Analysis.

T.22N., R.5E., W.M.

LEGEND

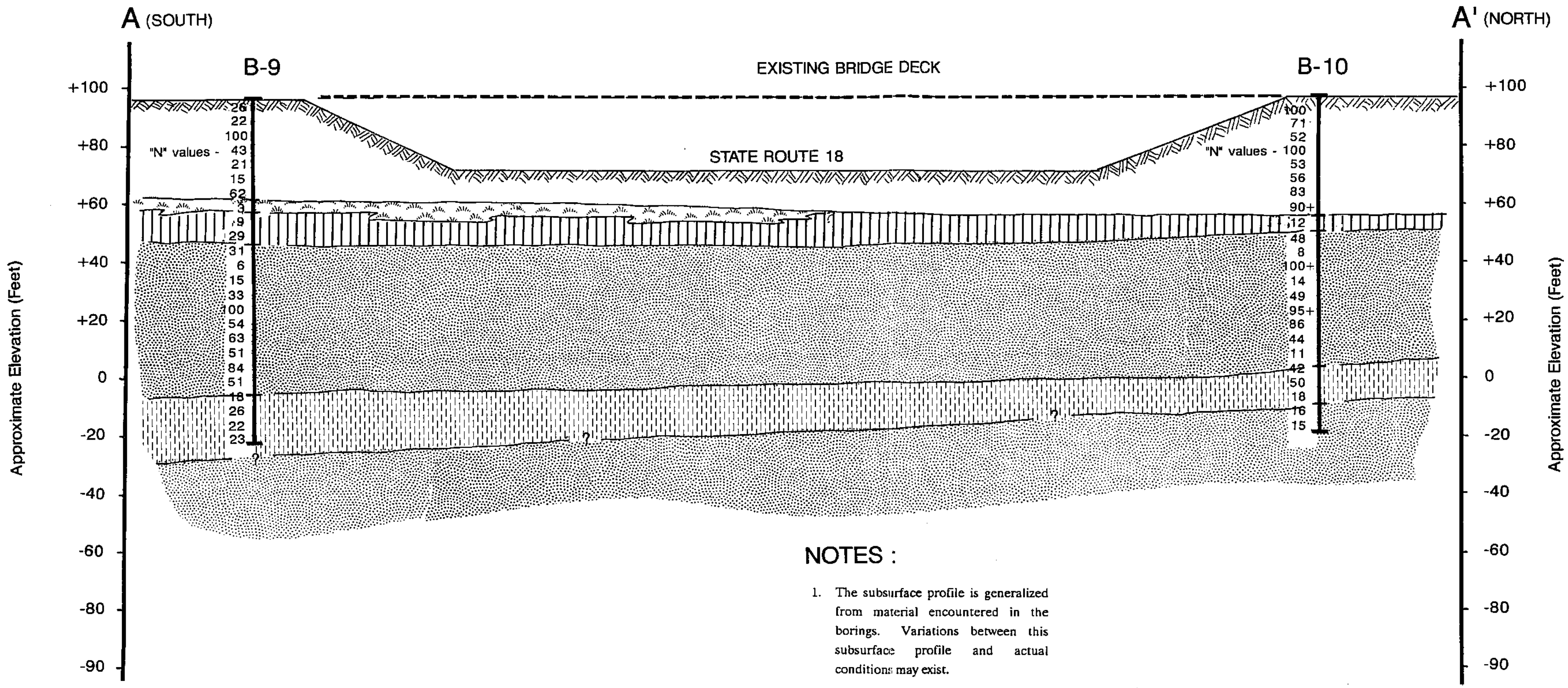
● B-1 APPROXIMATE TEST BORING LOCATION



REF: Based on WSDOT SR-167, 15th Street SW to South Grady Way Alternative Analysis.

TERRA ASSOCIATES Geotechnical Consultants	EXPLORATION LOCATION PLAN STATE ROUTE 167 SOUTH 212TH STREET EWS RAMP BRIDGE		
	Proj. No. 1630	Date 10-91	Figure 11

Sr # 167/129



NOTES :

1. The subsurface profile is generalized from material encountered in the borings. Variations between this subsurface profile and actual conditions may exist.
2. Existing topography and structure information shown on this drawing is compiled from the project plans for SR-167 prepared by Alpha Engineers, Inc. for WSDOT.

LEGEND:

- Roadway Fill; Medium Dense to Dense Silty Gravelly Sand
- Loose Sandy Silt
- Medium Dense to Dense Silty Sand
- Stiff to Hard Silt With Some Organics
- Peat

SCALE:

40 0 40 80

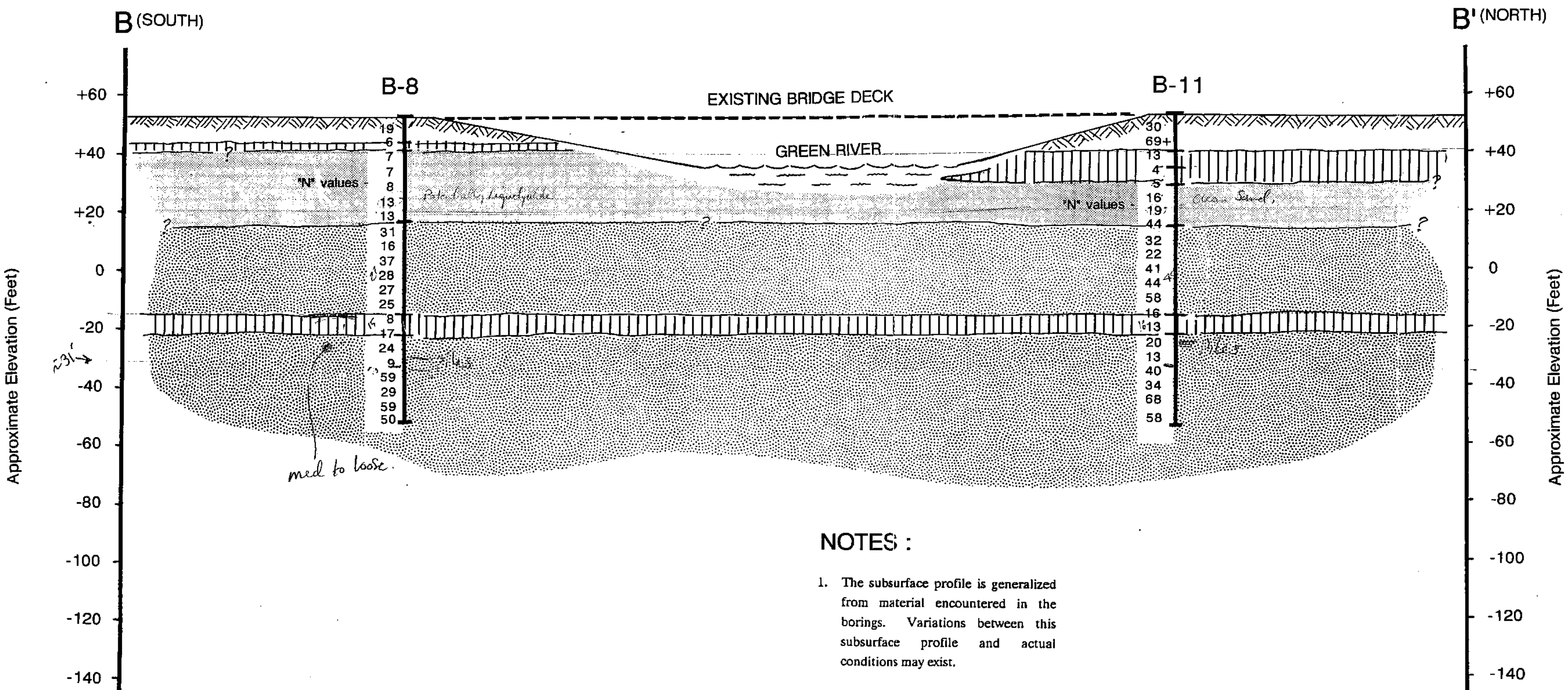
scale feet

HORIZONTAL & VERTICAL

TERRA ASSOCIATES
Geotechnical Consultants

GEOLOGIC CROSS SECTION
STATE ROUTE 167
STATE ROUTE 18 BRIDGE

Proj. No. 1630	Date 10-91	Figure 12



NOTES :

1. The subsurface profile is generalized from material encountered in the borings. Variations between this subsurface profile and actual conditions may exist.
2. Existing topography and structure information shown on this drawing is compiled from the project plans for SR-167 prepared by Alpha Engineers, Inc. for WSDOT.

LEGEND:

- Roadway Fill; Dense Silty Gravelly Sand
- Loose Sandy Silt
- Medium Dense to Dense Silty Sand With Occasional Silt Layers
- Medium to Stiff Silt With Some Organics
- Loose Silty Sand

SCALE:

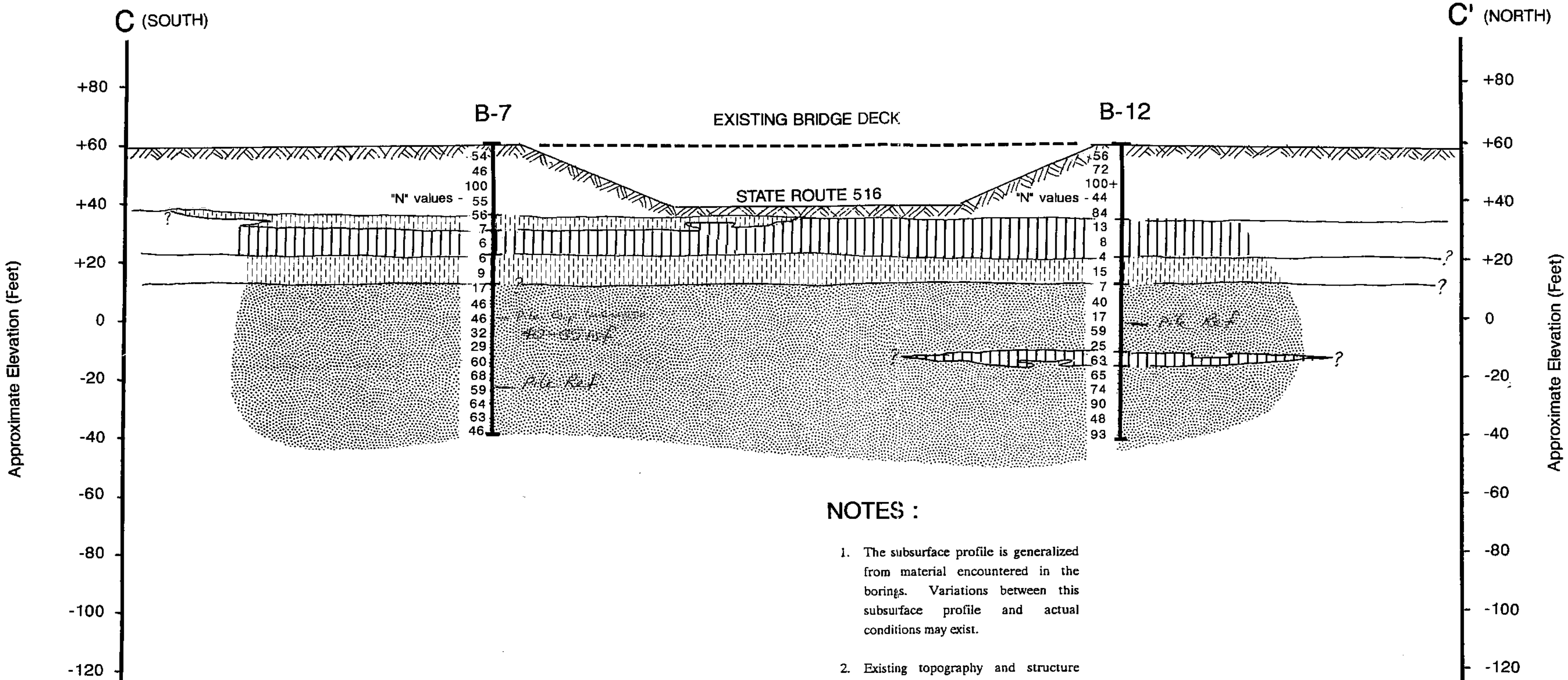
40 0 40 80

scale feet

HORIZONTAL & VERTICAL

TERRA ASSOCIATES
Geotechnical Consultants

GEOLOGIC CROSS SECTION STATE ROUTE 167 GREEN RIVER BRIDGE		
Proj. No. 1630	Date 10-91	Figure 13



NOTES :

1. The subsurface profile is generalized from material encountered in the borings. Variations between this subsurface profile and actual conditions may exist.

2. Existing topography and structure information shown on this drawing is compiled from the project plans for SR-167 prepared by Alpha Engineers, Inc. for WSDOT.

LEGEND:

Roadway Fill; Dense Silty Gravelly Sand

Loose Sandy Silt

Medium Dense to Dense Silty Sand and Gravelly Sand With Occasional Silt Layers

Medium to Stiff Silt With Some Organics

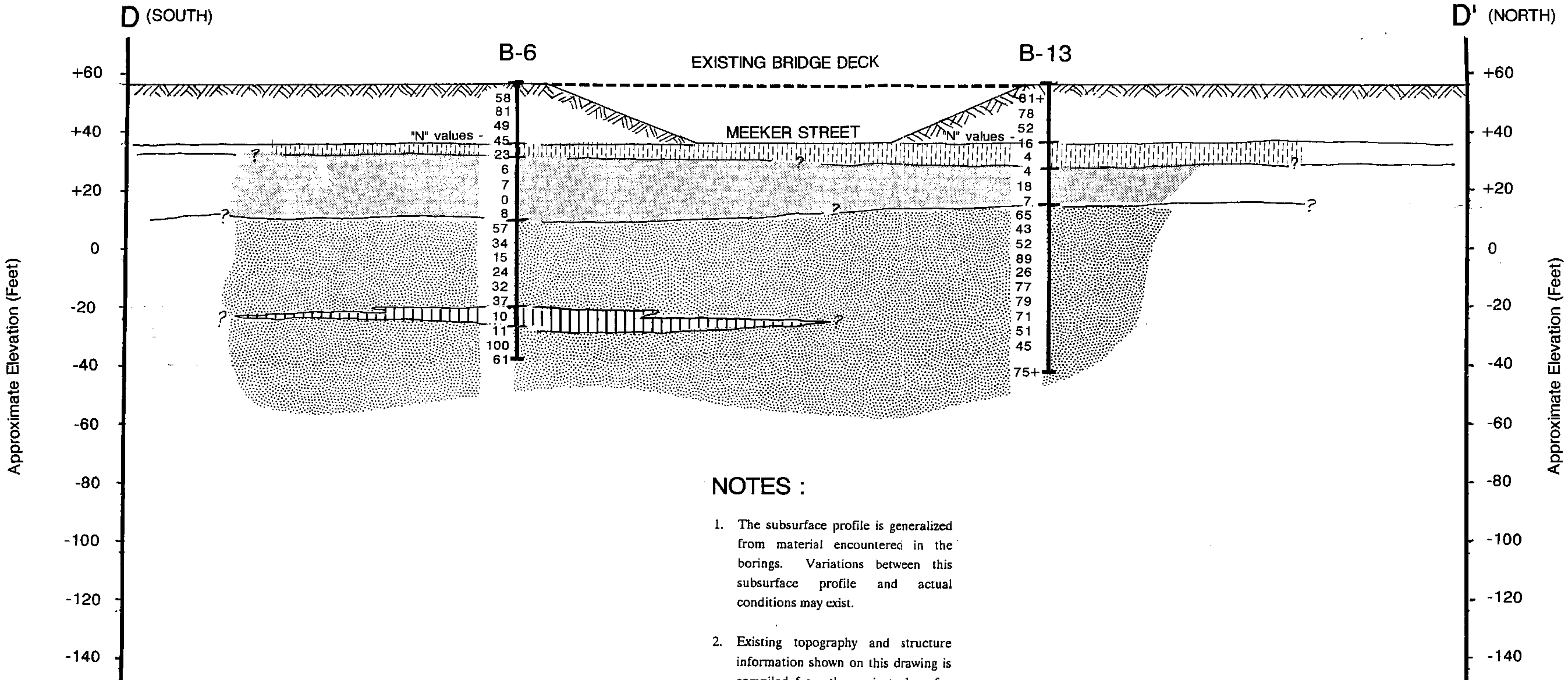
SCALE:

HORIZONTAL & VERTICAL

TERRA ASSOCIATES
Geotechnical Consultants

GEOLOGIC CROSS SECTION
STATE ROUTE 167
STATE ROUTE 516 BRIDGE

Proj. No. 1630	Date 10-91	Figure 14



NOTES :

1. The subsurface profile is generalized from material encountered in the borings. Variations between this subsurface profile and actual conditions may exist.

2. Existing topography and structure information shown on this drawing is compiled from the project plans for SR-167 prepared by Alpha Engineers, Inc. for WSDOT.

LEGEND:

- Roadway Fill; Dense Silty Gravelly Sand
- Loose Sandy Silt
- Medium Dense to Dense Silty Sand
- Medium to Stiff Silt With Some Organics
- Loose Silty Sand

SCALE:

40 0 40 80

scale feet

HORIZONTAL & VERTICAL

TERRA ASSOCIATES
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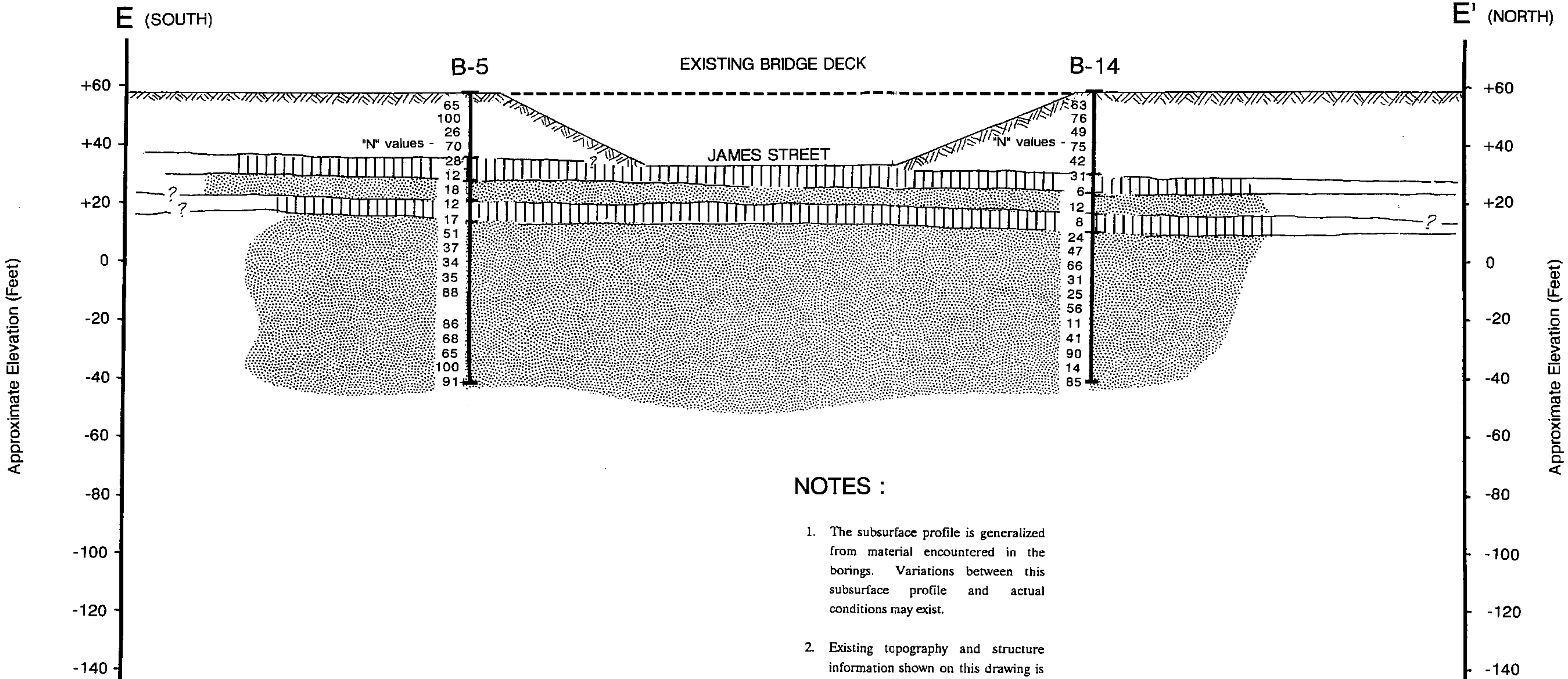
GEOLOGIC CROSS SECTION
STATE ROUTE 167
MEEKER STREET BRIDGE

Proj. No. 1630	Date 10-91	Figure 15



NOTES :

1. The subsurface profile is generalized from material encountered in the borings. Variations between this subsurface profile and actual conditions may exist.

2. Existing topography and structure information shown on this drawing is compiled from the project plans for SR-167 prepared by Alpha Engineers, Inc. for WSDOT.

LEGEND:

- Roadway Fill; Dense Silty Gravelly Sand
- Loose Sandy Silt
- Medium Dense to Dense Silty Sand With Occasional Silt Layers
- Medium to Stiff Silt With Some Organics

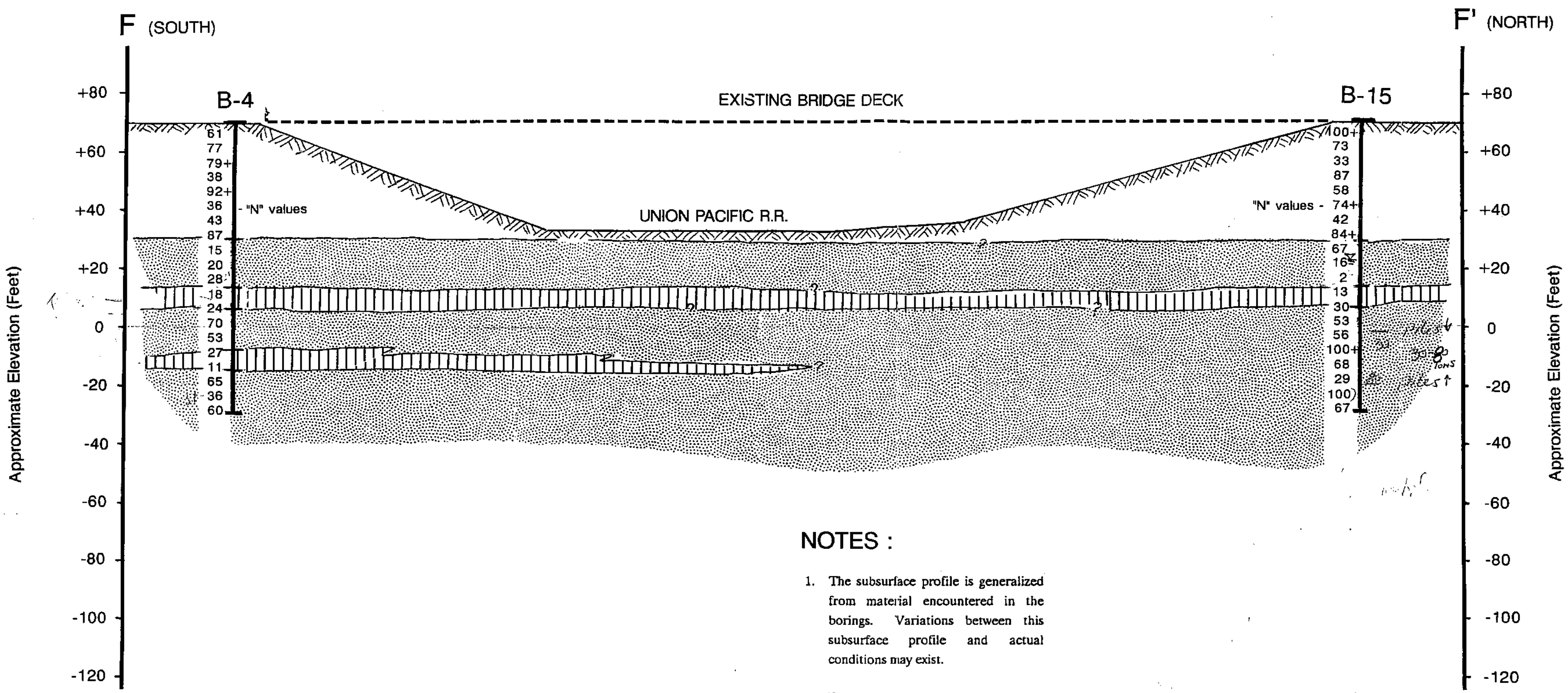
SCALE:

40 0 40 80

scale feet

HORIZONTAL & VERTICAL

TERRA ASSOCIATES Geotechnical Consultants	GEOLOGIC CROSS SECTION STATE ROUTE 167 JAMES STREET BRIDGE		
	Proj. No. 1630	Date 10-91	Figure 16



NOTES :

1. The subsurface profile is generalized from material encountered in the borings. Variations between this subsurface profile and actual conditions may exist.

2. Existing topography and structure information shown on this drawing is compiled from the project plans for SR-167 prepared by Alpha Engineers, Inc. for WSDOT.

LEGEND:

- Roadway Fill; Dense Silty Gravelly Sand
- Stiff Sandy Silt
- Medium Dense to Dense Silty Sand With Occasional Silt Layers
- Medium to Stiff Silt With Some Organics

SCALE:

40 0 40 80

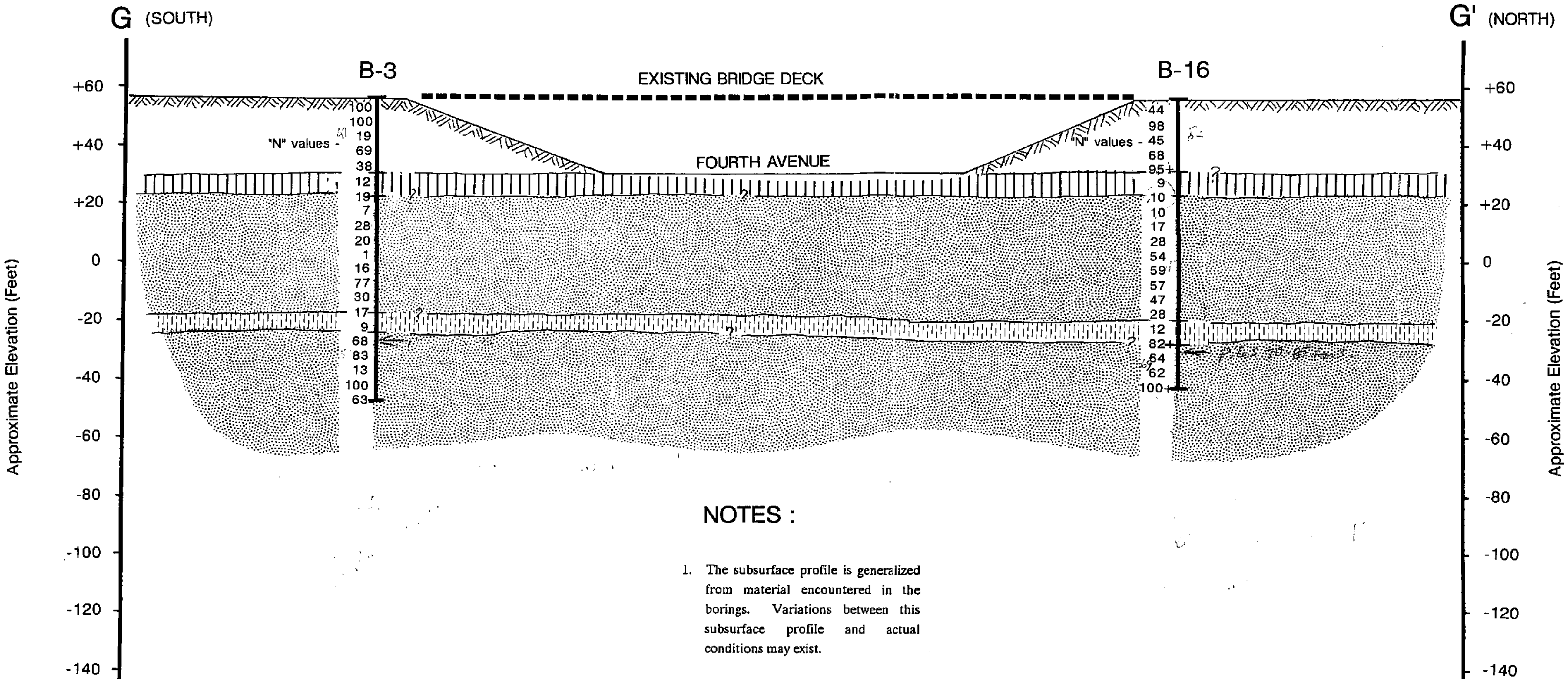
scale feet

HORIZONTAL & VERTICAL

TERRA ASSOCIATES
Geotechnical Consultants

GEOLOGIC CROSS SECTION
STATE ROUTE 167
UNION PACIFIC R.R. OVERPASS

Proj. No. 1630	Date 10-91	Figure 17



NOTES :

1. The subsurface profile is generalized from material encountered in the borings. Variations between this subsurface profile and actual conditions may exist.

2. Existing topography and structure information shown on this drawing is compiled from the project plans for SR-167 prepared by Alpha Engineers, Inc. for WSDOT.

LEGEND:

- Roadway Fill; Dense Silty Gravelly Sand
- Loose Sandy Silt
- Medium Dense to Dense Silty Sand
- Medium to Stiff Silt With Some Organics

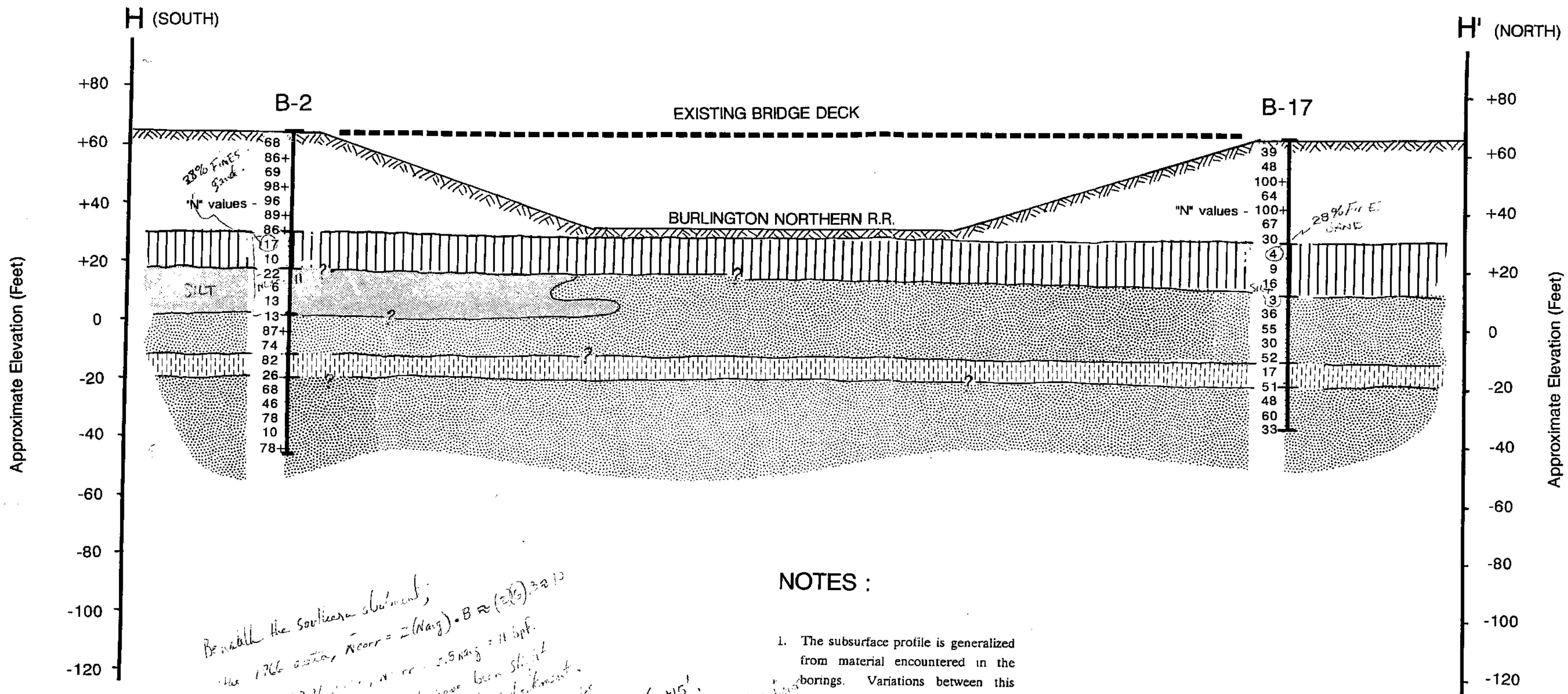
SCALE:

40 0 40 80

scale feet

HORIZONTAL & VERTICAL

TERRA ASSOCIATES Geotechnical Consultants	GEOLOGIC CROSS SECTION STATE ROUTE 167 FOURTH AVENUE BRIDGE		
	Proj. No. 1630	Date 10-91	Figure 18



NOTES :

1. The subsurface profile is generalized from material encountered in the borings. Variations between this subsurface profile and actual conditions may exist.
2. Existing topography and structure information shown on this drawing is compiled from the project plans for SR-167 prepared by Alpha Engineers, Inc. for WSDOT.

LEGEND:

- Roadway Fill; Dense Silty Gravelly Sand
- Loose Sandy Silt to Silty Fine Sand
- Medium Dense to Dense Silty Sand With Occasional Silt Layers
- Medium to Stiff Silt With Some Organics
- Loose Silty Sand With Silt Layers

SCALE:

40 0 40 80

scale feet

HORIZONTAL & VERTICAL

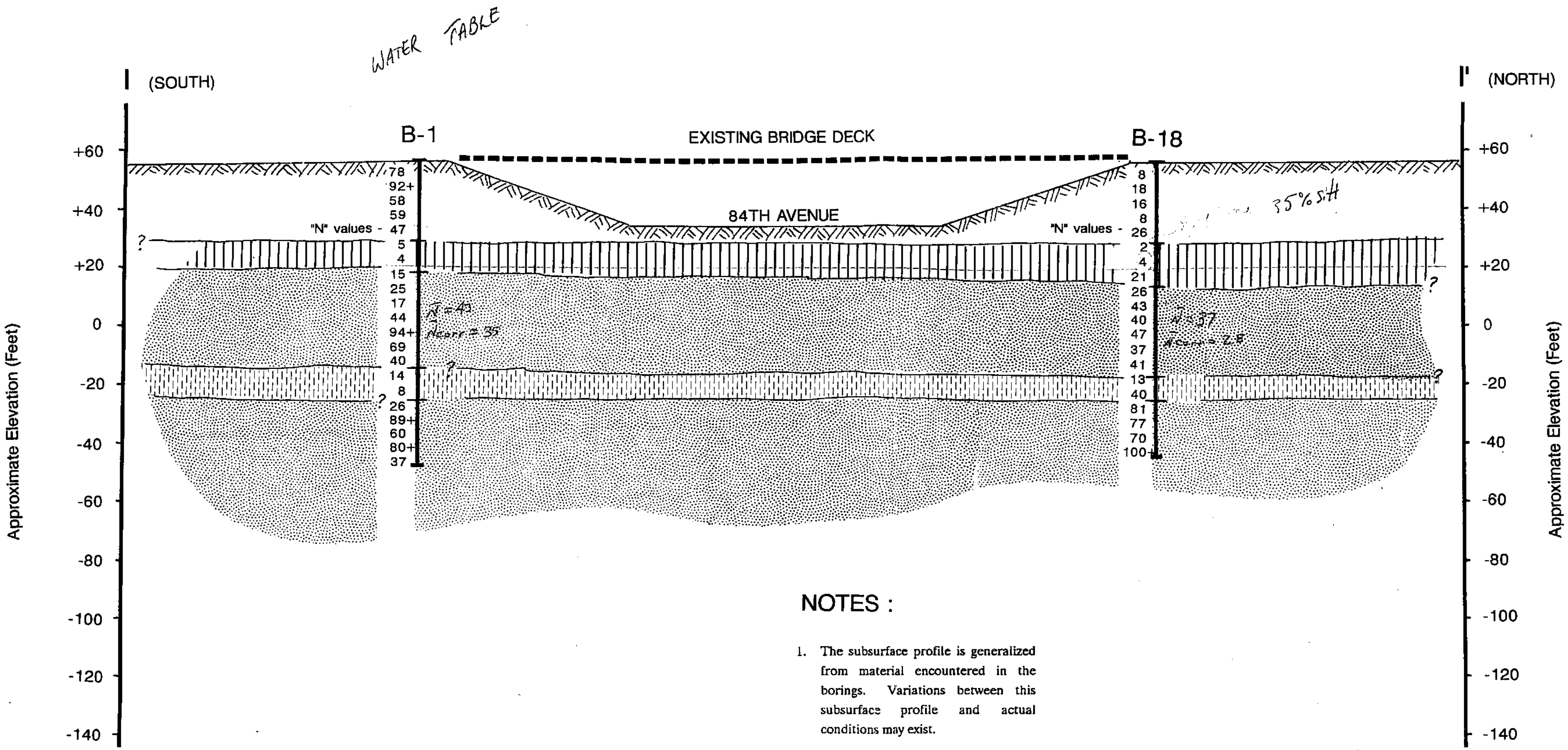
TERRA ASSOCIATES

Geotechnical Consultants

GEOLOGIC CROSS SECTION STATE ROUTE 167 B.N. R.R. OVERPASS		
Proj. No. 1630	Date 10-91	Figure 19

Beneath the southern abutment;

By correlation, the north abutment ... piers ... the same.



NOTES :

1. The subsurface profile is generalized from material encountered in the borings. Variations between this subsurface profile and actual conditions may exist.

2. Existing topography and structure information shown on this drawing is compiled from the project plans for SR-167 prepared by Alpha Engineers, Inc. for WSDOT.

LEGEND:

- Roadway Fill; Loose to Dense Silty Gravelly Sand
- Loose Sandy Silt
- Medium Dense to Dense Silty Sand With Occasional Gravel
- Medium to Stiff Silt With Some Organics

SCALE:

40 0 40 80

scale feet

HORIZONTAL & VERTICAL

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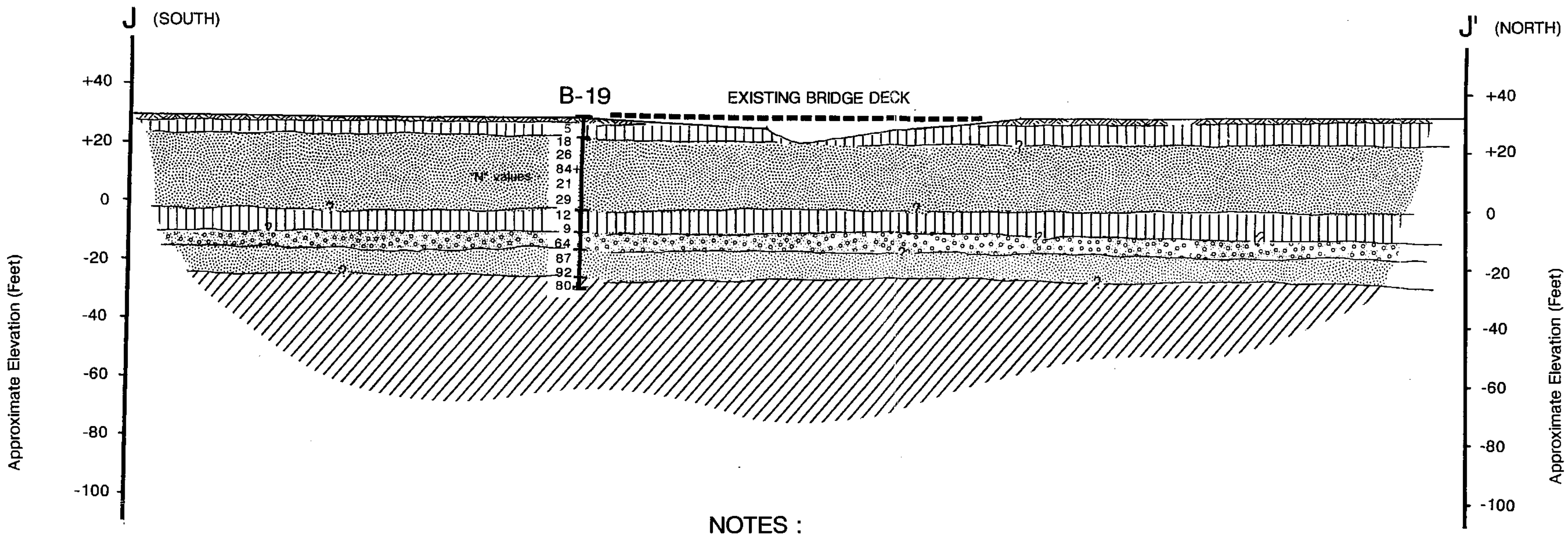
GEOLOGIC CROSS SECTION
STATE ROUTE 167
84TH AVENUE BRIDGE

Proj. No. 1630	Date 10-91	Figure 20



NOTES :

1. The subsurface profile is generalized from material encountered in the borings. Variations between this subsurface profile and actual conditions may exist.

2. Existing topography and structure information shown on this drawing is compiled from the project plans for SR-167 prepared by Alpha Engineers, Inc. for WSDOT.

LEGEND:

- Roadway Fill; Dense Silty Gravelly Sand
- Loose Sandy Silt /Soft Silt
- Medium Dense to Dense Silty Sand
- Dense Sandy Gravel
- Hard clayey Silt to Siltstone

SCALE:

40 0 40 80

scale feet

HORIZONTAL & VERTICAL

TERRA ASSOCIATES
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GEOLOGIC CROSS SECTION
STATE ROUTE 167
212th STREET EW-S RAMP

Proj. No. 1630	Date 10-91	Figure 21

APPENDIX A

SUBSURFACE EXPLORATION

Our subsurface exploration program consisted of drilling 20 test borings to a maximum depth of 119 feet. This work was performed during June and July of 1991. The test borings were drilled using a truck mounted B-61 drill rig operated by Drilling Unlimited of Seattle. The borings were advanced using continuous flight hollow stem augers. The general boring locations are shown on Figure 1. Specific boring locations are shown on Figures 2 through 11.

The drilling of the test borings was continuously observed by an engineering geologist from Terra Associates. A continuous log of subsurface conditions encountered in the borings was maintained. In each boring, standard penetration tests were performed at approximately five foot intervals. The results of these tests are shown as N-values on the borings logs which are presented on Figures A-2 through A-21. In addition, a 2.5-inch diameter split barrel sampler with rings and liners was also used to obtain relatively undisturbed samples of the finer grained soils encountered in the exploration. All soils encountered in the subsurface exploration were visually classified in the field using the Unified Soil Classification, ASTM T-2487. All samples obtained from the subsurface exploration were placed in closed containers and brought back to our laboratory for further evaluation and testing.

SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			LETTER SYMBOL	GRAPH SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS — More than 50% material larger than No. 200 sieve size.	GRAVELS — More than 50% of coarse fraction is larger than No. 4 sieve.	Clean Gravels (less than 5% fines).	GW		Well-graded gravels, gravel-sand mixtures, little or no fines.
			GP		Poorly-graded gravels, gravel-sand mixtures, little or no fines.
		Gravels with fines.	GM		Silty gravels, gravel-sand-silt mixtures, non-plastic fines.
			GC		Clayey gravels, gravel-sand-clay mixtures. plastic fines.
	SANDS — More than 50% of coarse fraction is smaller than No. 4 sieve.	Clean Sands (less than 5% fines).	SW		Well-graded sands, gravelly sands, little or no fines.
			SP		Poorly-graded sands or gravelly sands, little or no fines.
		Sands with fines.	SM		Silty sands, sand-silt mixtures, non-plastic fines.
			SC		Clayey sands, sand-clay mixtures, plastic fines.
FINE GRAINED SOILS — More than 50% material smaller than No. 200 sieve size.	SILTS AND CLAYS — Liquid limit is less than 50%.		ML		Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
			CL		Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.
			OL		Organic silts and organic clays of low plasticity.
	SILTS AND CLAYS — Liquid limit is greater than 50%.		MH		Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic.
			CH		Inorganic clays of high plasticity, fat clays.
			OH		Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS			PT		Peat and other highly organic soils.

DEFINITION OF TERMS AND SYMBOLS

I	2" OUTER DIAMETER SPLIT SPOON SAMPLER	C	TORVANE READING, tsf
II	2.4" INNER DIAMETER RING SAMPLER OR SHELBY TUBE SAMPLER	q_u	PENETROMETER READING, tsf
P	SAMPLER PUSHED	W	MOISTURE, percent of dry weight
*	SAMPLE NOT RECOVERED	pcf	DRY DENSITY, pounds per cubic foot
▽	WATER LEVEL (DATE)	LL	LIQUID LIMIT, percent
	WATER OBSERVATION WELL	PI	PLASTIC INDEX
		N	STANDARD PENETRATION, blows per foot

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KEY TO BORING LOGS

STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. **1630** | Date **10-91** | Figure **A-1**

BORING NO. 1

Logged By DBG

Date 6-3-91

ELEV. 55±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Gray-Tan, gravelly, silty SAND, moist dense. (FILL)	5	I	78	5
			10	I	92+	5
		Scattered cobbles.	15	I	58	10
			20	I	59	7
		29	25	I	47	8
	ML	Gray, fine sandy SILT with trace organics, wet, very loose.	30	▼ I	5	34
		20	35	I	4	33
	SM	Black to dark brown, silty SAND with trace organics, wet, medium dense, some SAND with silt.	40	I	15	32
			45	I	25	28
			50	I	17	27
		Becomes more dense.	55	I	44	28
			60	I	94+	23
			65	I	69	30

BORING CONTINUED ON NEXT PAGE

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BORING LOG

STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-91	Figure A-2

BORING NO. 1

Logged By DBG

Date 6-3-91

ELEV. 55±

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Silty SAND, dense. -14			40	*
	ML / CL	Gray SILT with organics, moist, stiff.	70		14	47
			75		8	
	SW / GW	Black, fine gravelly SAND, fine to coarse grained, wet, medium dense to dense.	80		26	24
			85		89+	13
		Becomes slightly silty.	90		60	12
			95			
	SP / SM	Black, gravelly SAND			80+	21
			100			
		Becomes very gravelly.			37	2

Boring completed at depth 104 feet.
Groundwater noted at 28 feet at time of drilling.
*Sample not recovered.

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BORING LOG

STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. 1630 | Date 10-91 | Figure A-2

BORING NO. 2

Logged By DBG

Date 6-5-91

ELEV. 65±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Gray-Tan, slightly silty, gravelly SAND, fine to medium grained, moist dense. (FILL)		I	68	6
			5			
				I	86+	7
			10			
				I	69	9
			15			
				I	98+	4
			20			
				I	96	6
			25			
		(gravelly silty SAND)		I	89+	8
			30			
				I	86+	*
			35 ▼			
	ML	Gray-Brown, sandy SILT, wet, stiff.		I	17	8
			40			
				I	10	40
			45			
	SM/ML	Black, silty SAND, fine grained, wet, loose to medium dense. Some sandy SILT, wet.		I	22	33
			50			
				I	6	26
			55			
	ML	Dark gray to greenish-gray, sandy SILT, wet stiff.		I	13	56
			60			
				II	13	
	SM	Silty SAND	65			

BORING CONTINUED ON NEXT PAGE

BORING NO. 2

Logged By DBG

Date 6-5-91

ELEV. 65±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Gray to black, silty SAND, fine grained, wet, medium dense to dense.			87+	23
			70			
					74	*
			75			
					82+	29
			80			
	ML	Gray, sandy SILT wet, stiff.			26	38
			85			
	SM	Black, silty SAND, fine to medium grained, wet, dense.			68	20
			90			
					46	30
			95			
	ML	Gray, sandy SILT, wet, stiff.			78	29
			100			
	SM	Black silty SAND, fine to medium grained, wet, dense.			10	28
			105			
					78+	20

Boring completed at depth 109 feet.
Groundwater noted at 36 feet.
*No Recovery

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BORING LOG
STATE ROUTE 167
KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-91	Figure A-3

BORING NO. 3

Logged By DBG

Date 6-7-91

ELEV. 57±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Brown slightly silty SAND and GRAVEL with scattered cobbles, dry to moist, dense. (FILL)	5	I	100	4
			10	I	100	5
	SM	Becomes less gravelly	15	I	19	10
			20	I	69	7
			25	I	38	7
	ML	Brown-gray SILT with trace organics, wet, stiff.	30 ▼	I	12	44
	SM	Black, silty SAND, fine grained very wet, medium dense.	35	I	19	26
		Becomes more SILT and loose with trace organics.	40	I	7	33
			45	I	28	26
			50	I	20	36
		Becomes slightly silty, saturated and loose.	55	I	1	25
			60	I	16	27
		Becomes medium dense to dense.	65	I	77	*

BORING CONTINUED ON NEXT PAGE

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BORING LOG

STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. 1630 | Date 10-91 | Figure A-4

BORING NO. 3

Logged By DBG

Date 6-7-91

ELEV. 57±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)	
	SM	Black, slightly silty SAND, wet, medium dense.	70	II	30	21	
	ML	Gray SILT with trace organics, wet, stiff.	75	I	17	51	
			80	II	9		
	SM	Black, slightly silty SAND fine grained, wet, dense.	85	I	68	27	
		Becomes more silty and occasionally loose.	90	I	83	23	
			95	I	13	17	
			100	I	100	15	
				I	63	15	

Boring completed at depth 104 feet.
Groundwater noted at 30 feet.

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BORING LOG
STATE ROUTE 167
KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-91	Figure A-4

BORING NO. 4

Logged By DBG

Date 6-11-91

ELEV. 70±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Gray-tan, silty, gravelly SAND, moist, dense. (FILL)		I	61	7
			5	I	77	7
			10	I	79+	6
			15	I	38	8
			20	I	92+	10
			25	I	36	8
			30	I	43	9
			35	I	87	7
			40	I	15	22
	SM/SP	Black, slightly silty SAND, fine grained, wet, medium dense.	45 ▼	I	20	23
			50	I	28	35
	ML	Greenish-gray, sandy SILT, with shell fragments, wet, stiff.	55	I	18	57
			60	I	24	27
			65			

BORING CONTINUED ON NEXT PAGE

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BORING LOG

STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. 1630 | Date 10-91 | Figure A-5

BORING NO. 4

Logged By DBG
Date 6-11-91

ELEV. 70±

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)	
	SM	Black, silty SAND, fine grained, wet, dense.		I	70	17	
			70	I	53	25	
			75				
	ML	Dark gray, sandy SILT, wet, medium dense.		I	27	31	
			80	II	11	27	
			85				
	SM	Black silty, SAND fine grained, wet, medium dense.		I	65	23	
			90	I	36	29	
			95	I	60	22	

Boring completed at depth 99 feet.
Groundwater noted at 45 feet.

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BORING LOG
STATE ROUTE 167
KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-91	Figure A-5

BORING NO. 5

Logged By DBG

Date 6-12-91

ELEV. 58±

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Gray-tan silty gravelly SAND, moist, dense. (FILL)		I	65	6
			5			
				I	100	*
			10			
				I	26	10
			15			
				I	70	11
			20			
	ML	Gray sandy SILT, wet, stiff.		I	28	41
			25 ▼			
				I	12	37
	SM	Black silty SAND, fine grained, wet, medium dense.	30			
				I	18	29
			35			
				I	12	28
	ML	Gray sandy SILT, wet, stiff becomes greenish-gray.	40			
				I	17	43
	SM	Black silty SAND, fine grained, wet, dense.	45			
				I	51	36
			50			
		Occ'l thin SILT layers.		I	37	29
			55			
				I	34	31
			60			
				I	35	32
			65			

BORING CONTINUED ON NEXT PAGE

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BORING LOG
STATE ROUTE 167
KING COUNTY, WASHINGTON

Proj. No. 1630 | Date 10-91 | Figure A-6

BORING NO. 5

Logged By DBG

Date 6-12-91

ELEV. 58±

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Black, silty SAND, fine grained, wet, dense.		I	88	27
			70			
				I		24
			75			
				I	86	24
			80			
				I	68	31
			85			
	SP	Black SAND, medium grained, dense.		I	65	25
			90			
				I	100	17
			95			
				I	91+	16

Boring completed at depth 99 feet.
Groundwater noted at 26 feet.

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BORING LOG
STATE ROUTE 167
KING COUNTY, WASHINGTON

Proj. No. 1630 | Date 10-91 | Figure A-6

BORING NO. 6

Logged By DBG

Date 6-13-91

ELEV. 57±

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Gray-tan, silty, gravelly SAND, moist, dense. (FILL)		I	58	10
			5			
				I	81	7
			10			
				I	49	9
			15			
				I	45	6
			20			
	ML	Brown SILT with organics, moist, stiff.		II	23	32
			25			
				I	6	29
	SM	Black silty SAND, very fine to fine grained, wet, loose, with sandy SILT lenses.	30 ▼			
				I	7	24
			35			
	SP	Becomes slightly silty and very loose.		I	0	39
			40			
				I	8	31
			45			
	SM	Becomes dense.		I	57	29
			50			
				I	34	23
			55			
				I	15	22
		Wood.	60			
				I	24	29
		Wood.	65			

BORING CONTINUED ON NEXT PAGE

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BORING LOG

STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. 1630 | Date 10-91 | Figure A-7

BORING NO. 6

Logged By DBG

Date 6-13-91

ELEV. 57±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Black, slightly silty SAND, fine grained, wet, dense.		I	32	28
			70 -13			
			-15	I	37	27
			75			
	ML	Gray, sandy SILT, wet, stiff.	-19	I	10	31
			80			
				I	11	35
	SW	Black SAND and gravelly SAND, medium to coarse grained, wet, dense.	85 -27	I	100	25
			90			
				I	61	12

Boring completed at depth 94 feet.
Groundwater noted at 31 feet.

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BORING LOG

STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-91	Figure A-7

BORING NO. 7

Walls 2 & 3

Logged By DBG

Date 6-14-91

ELEV. 60±

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Gray-tan, silty, gravelly SAND, moist, dense. (FILL)		I	54	8
			5			
				I	46	7
			10			
		Becomes very moist.		I	100	8
			15			
				I	55	6
			20			
		Becomes wet. 8		I	56	35
	ML	Gray-brown, sandy SILT with some organics, wet, stiff. 22	25			
			▼	I	7	31
	SM	Black, silty SAND fine grained, wet, loose.	30			
				I	6	36
			35			
		22		I	6	40
	ML	Gray SILT, wet, soft.	40			
			consol	I	9	32
		12	45			
	SP	Black, slightly silty SAND, fine grained, wet, medium dense.		I	17	31
			50			
				I	46	26
			55			
				I	46	24
	SM	Becomes dense and silty, Occ'l silt layers.	60			
				I	32	37
			65			

BORING CONTINUED ON NEXT PAGE

BORING NO. 7

Logged By DBG

Date 6-14-91

ELEV. 60±

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Black, silty SAND, fine to medium grained, wet.	70	I	29	24
		Black SAND, fine to medium grained, wet, dense.	75	I	60	23
			80	I	68	*
			85	I	59	*
				I	64	26
	SP/GP	Black SAND and GRAVEL, wet, dense.	90	I	63	26
			95	I	46	15

Boring completed at depth 99 feet.
Groundwater noted at 27 feet.

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BORING LOG
STATE ROUTE 167
KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-91	Figure A-8

BORING NO. 8

Logged By DBG
Date 6-17-91

ELEV. 54±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SP	Brown SAND, medium grained, moist, medium dense. (FILL)	5	I	19	5
				I	6	5
	ML	Brown sandy SILT, loose.	10			
	SP	Dark brown, slightly silty SAND, fine grained, moist, loose.	15	I	7	17
			20	I	7	12
	SM	Lenses of silty SAND.	25	I	8	25
			30 ▼	I	13	27
	SP/SM	Black SAND, fine to coarse grained, wet medium dense.	35	I	13	21
			40	I	31	28
			45	I	16	*
	SP	Becomes fine to medium grained.	50	I	37	30
			55	I	28	25
			60	I	27	36
			65	I	25	26

BORING CONTINUED ON NEXT PAGE

BORING NO. 8

Logged By DBG

Date 6-17-91

ELEV. 54±

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	ML	Gray SILT, wet, stiff.		I	8	35
		Becomes sandy.	70			
	SM	Black silty SAND, fine grained, wet, medium dense.	75	II	17	36
			80	I	24	31
	ML	Gray, sandy SILT with trace organics, wet, stiff.	85	I	9	44
	SM / Gp	Black silty SAND and sandy GRAVEL, wet, dense.	90	I	59	22
			95	I	29	20
				I	59	26
	SW	Becomes well graded	100			
				I	50	19

Boring completed at depth 104 feet.
Groundwater noted at 30 feet.

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BORING LOG

STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. 1630 | Date 10-91 | Figure A-9

BORING NO. 9

Logged By DBG

Date 6-18-91

ELEV. 96±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Gray-brown, very silty, gravelly SAND, fine to medium grained, moist, medium dense. (Fill)		I	26	15
			5	I	22	14
			10			
		Very silty.		I	100	9
			15	I	43	17
			20			
		Medium dense.		I	21	18
			25	I	15	11
			30	I	62	7
		Becomes dense.	35			
	PT	Brown Peat, wet, soft.		I	3	277
			40			
	ML	Gray sandy SILT, wet, loose. Occ'l sand layers; SILT with clay	Consol	II	9	44
			45	I	29	24
	SM	Black silty SAND, fine grained, wet, medium dense.	50	I	31	33
			55			
	SP	Becomes slighty silty, SAND with silt.		I	6	22
			60			
			65	I	15	26

BORING CONTINUED ON NEXT PAGE

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BORING LOG

STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. 1630 | Date 10-91 | Figure A-10

BORING NO. 9

Logged By DBG

Date 6-18-91

ELEV. 96±

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SW	Black gravelly SAND, wet, dense		I	33	16
			70			
		Becomes more gravelly		I	100	15
			75			
				I	54	14
			80			
				I	63	13
			85			
				I	51	6
			90			
				I	84	*
			95			
	SM	Black, very silty SAND		I	51	47
			100			
	ML	Gray, slighty gravelly, fine to coarse sandy SILT, wet, medium dense.		I	18	13
			105			
				I	26	15
			110			
				I	22	15
		Some wood.	115			
				I	23	*

Boring completed at depth 119 feet.
Groundwater noted at 37 feet.

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BORING LOG

STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-91	Figure A-10

BORING NO. 10

Logged By DBG

Date 6-20-91

ELEV. 96±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Tan, silty, gravelly SAND, fine to medium grained, moist, dense. (Fill)	5	I	100	10
			10	I	71	9
			15	I	52	14
		Becomes gray-tan.	20	I	100	11
			25	I	53	13
			30	I	56	14
			35	I	83	10
			40	I	90+	*
	ML	Gray sandy SILT, wet, soft. Consol	45	II	12	33
	SM	Black silty SAND, fine grained, wet, medium dense.		I	48	23
		Some gravelly SAND with silt.	50			
	SW	Black SAND, fine to coarse grained, wet, loose.	55	I	8	38
		Wood entire sample.	60	I	100+	75
		Becomes gravelly.	65	I	14	19

BORING CONTINUED ON NEXT PAGE

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BORING LOG

STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. 1630 | Date 10-91 | Figure A-11

BORING NO. 10

Logged By DBG

Date 6-20-91

ELEV. 96±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
				I	49	8
			70			
	SM	Becomes silty and dense.		I	95+	21
			75			
				I	86	19
			80			
				I	44	*
			85			
		Becomes loose, with extensive organic matter.		I	11	50
			90			
	ML	Gray fine sandy SILT, wet, hard.		I	42	26
			95			
				I	50	23
			100			
				I	18	15
			105			
				I	16	16
			110			
				I	15	17

Boring completed at depth 114 feet.
Groundwater noted at 44 feet.

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BORING LOG
STATE ROUTE 167
KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-91	Figure A-11

BORING NO. 11

Logged By DBG

Date 6-24-91

ELEV. 54±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Tan, slightly gravelly, slightly silty SAND, medium grained, moist, medium dense. (FILL)	5	I	30	5
		Concrete fragments.	10	I	69+	14
		Becomes very silty and loose.	15	I	13	15
	ML	Tan sandy SILT, wet, soft.	20	I	4	36
	SM		25	II	5	31
		Tan to brown silty SAND, fine grained, moist to wet, loose to medium dense.	30	I	16	13
		(Lenses of clean SAND)	35	I	19	24
		Black slightly silty SAND, fine to medium grained, wet, medium dense to dense.	40	I	44	23
	SP		45	I	32	35
			50	I	22	26
			55	I	41	34
			60	I	44	38
			65	I	58	29

BORING CONTINUED ON NEXT PAGE

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BORING LOG

STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-91	Figure A-12

BORING NO. 11

Logged By DBG

Date 6-24-91

ELEV. 54±

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	ML	Gray sandy SILT, wet, stiff.	70	I	16	32
				I	13	30
	SM	Gray very silty SAND, fine grained, wet, medium dense.	75	I	20	34
			80	I	13	28
			85	I	40	29
	SM/SW	Black silty SAND to gravelly SAND, wet, dense.	90	I	34	29
			95	I	68	*
			100	I	58	17

Boring completed at depth 104 feet.
Groundwater noted at 28 feet.

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BORING LOG
STATE ROUTE 167
KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-91	Figure A-12

BORING NO. 12

Logged By DBG

Date 6-24-91

ELEV. 59±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Tan to gray, silty, gravelly SAND, fine to medium grained, moist to wet, dense. (FILL)	5	I	56	10
			10	I	72	7
			15	I	100+	10
			20	I	44	8
			25	I	84	6
	SM	Gray to black, silty SAND, fine grained, moist, loose to medium dense.	30	I	13	32
	SP	(Lenses of clean SAND)	35	I	8	33
	ML	Gray, fine sandy SILT with trace organics, wet, soft.	40	I	4	35
		Becomes stiff.	45	II	15	46
	SM	Black silty SAND fine grained wet, loose	50	I	7	34
		(Some SILT lenses)	55	I	40	25
	SP	Black SAND, wet, dense.	60	I	17	29
			65	I	59	21

BORING CONTINUED ON NEXT PAGE

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BORING LOG

STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. 1630 | Date 10-91 | Figure A-13

BORING NO. 12

Logged By DBG

Date 6-24-91

ELEV. 59±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)	
				I	25	*	
			70				
	SM	Black silty SAND with occ'l silt layers.		I	63	25	
			75				
				I	65	23	
			80				
	SP	Becomes less silty.		I	74	*	
			85				
				I	90	29	
			90				
				I	48	21	
	SP/GP	Black SAND and GRAVEL wet, dense.	95				
				I	93	13	

Boring completed at depth 99 feet.
Groundwater noted at 32 feet.

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BORING LOG
STATE ROUTE 167
KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-31	Figure A-13

BORING NO. 13

Logged By DBG

Date 6-26-91

ELEV. 57±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Gray-tan, gravelly, silty SAND, fine to medium grained, moist, dense. (FILL)	5	I	81+	9
			10	I	78	9
			15	I	52	7
		Becomes slightly silty and medium dense.	20	I	16	7
	OL	Dark brown, sandy, organic SILT, moist, loose.	25	II	4	22
	SP	Black SAND, fine to medium grained, wet, loose.	30 ▼	I	4	24
			35	I	18	28
			40	I	7	20
			45	I	65	11
	SW	Becomes fine to coarse grained with small gravels, dense.	50	I	43	24
	SM	Becomes silty SAND.	55	I	52	21
			60	I	89	20
	SP	Becomes less silty	65	I	26	26

BORING CONTINUED ON NEXT PAGE

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BORING LOG

STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-91	Figure A-14

BORING NO. 13

Logged By DBG

Date 6-26-91

ELEV. 57±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SP	Black SAND, fine to medium grained, wet, dense.			77	18
			70			
					79	18
			75			
					71	20
			80			
					51	*
			85			
					45	33
			90			
			95			
	SW	Black SAND with gravel, wet, dense.				
					75+	17

Boring completed at depth 99 feet.
Groundwater noted at 30 feet.

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BORING LOG
STATE ROUTE 167
KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-91	Figure A-14

BORING NO. 14

Logged By DBG

Date 6-26-91

ELEV. 58±

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Gray-tan, silty, gravelly SAND, moist, dense. (FILL)		I	63	6
			5	I	76	7
			10	I	49	7
			15	I	75	6
			20	I	42	9
			25			
		Becomes medium dense.		I	31	34
			30			
	ML	Gray, sandy SILT wet, soft.		I	6	34
			35 ▼			
	SM	Black silty SAND, wet medium dense.		I	12	30
			40			
	ML	Gray, slightly clayey SILT, wet, soft to stiff.	45	I	8	36
	SM	Gray to black, silty SAND, fine grained wet, medium dense to dense.	50	I	24	38
			55	I	47	28
		Becomes less silty.	60	I	66	25
			65	I	31	35

BORING CONTINUED ON NEXT PAGE

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BORING LOG

STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. 1630 | Date 10-91 | Figure A-15

BORING NO. 14

Logged By DBG

Date 6-26-91

ELEV. 58±

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Black silty SAND, fine grained, wet, medium dense to dense.		I	25	34
			70			
				I	56	25
			75			
	ML	Dark gray sandy SILT, wet, stiff.		I	11	31
			80			
	SM	Black silty SAND, fine grained, wet, dense.		I	41	25
			85			
				I	90	23
			90			
	ML	Gray sandy SILT, wet, stiff.		I	14	25
			95			
	SM	Gray silty SAND, fine grained, wet, dense.		I	85	18

Boring completed at depth 99 feet.
Groundwater noted at 36 feet.

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BORING LOG
STATE ROUTE 167
KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-91	Figure A-15

BORING NO. 15

Logged By DBG

Date 6-27-91

ELEV. 70±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Gray-tan, silty, gravelly SAND, fine to medium grained, moist, dense. (FILL)		I	100+	7
			5			
				I	73	5
			10			
				I	33	5
			15			
		Becomes medium dense.		I	87	5
			20			
				I	58	8
			25			
				I	74+	6
			30			
				I	42	11
			35			
		Becomes wet.		I	84+	8
			40			
	SM SP	Black, silty SAND, fine grained, wet, dense.		I	67	29
			45			
			▼	II	16	26
		(Some clean SAND lenses)	50			
				I	2	28
			55			
	ML	Gray, SILT, wet, stiff.		I	13	39
			60			
	SM	Black, silty SAND, fine to medium grained, wet, medium dense.		I	30	23
			65			

BORING CONTINUED ON NEXT PAGE

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BORING LOG

STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-91	Figure A-16

BORING NO. 15

Logged By DBG

Date 6-27-91

ELEV. 70±

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)	
	SM	Black silty SAND, fine grained, with occ'l silty interbeds, wet, dense.		I	53	19	
			70				
				I	56	21	
			75				
				I	100+	23	
			80				
				I	68	24	
			85				
	ML	Gray sandy SILT, wet, stiff to hard.		I	29	27	
			90				
	SM	Black silty SAND, fine grained, wet, dense.		I	100+	17	
			95				
				I	67		

Boring completed at depth 99 feet.
Groundwater noted at 47 feet.

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BORING LOG

STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-91	Figure A-16

BORING NO. 16

Logged By DBG

Date 7-1-91

ELEV. 57±

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Brown, silty, gravelly SAND, fine to medium grained, moist, dense. (FILL)	5		44	6
			10		98	7
		Becomes gray to tan	15		45	6
			20		68	9
			25		95+	5
	ML SM	Gray, sandy SILT with trace organics, wet, soft, lenses of silty SAND	30		9	38
			35		10	40
	SM	Black silty SAND, fine grained, wet, medium dense.	40		10	*
		(some sandy SILT lenses)	45		17	38
			50		28	27
			55		54	25
		Becomes dense.	60		59	22
	SP	Becomes less silty.	65		57	*

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BORING LOG

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KING COUNTY, WASHINGTON

Proj. No. 1630 | Date 10-91 | Figure A-17

BORING NO. 16

Logged By DBG

Date 7-1-91

ELEV. 57±

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SP	Black SAND, fine grained, wet, dense.			47	20
			70			
					28	27
			75			
	ML	Gray SILT and sandy SILT, wet, soft to stiff.			12	26
			80			
	SP	Black slightly silty SAND, fine to medium grained, wet, dense.			82+	15
			85			
					64	21
			90			
					62	21
			95			
	SW	Becomes fine to coarse and gravelly.			100+	10

Boring completed at depth 99 feet.
Groundwater noted at 26 feet.

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STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-31	Figure A-17

BORING NO. 17

Logged By DBG

Date 7-1-91

ELEV. 65±

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Gray-tan, silty, gravelly SAND fine to medium grained, moist, medium dense to dense. (FILL)		I	39	10
			5	I	48	5
			10	I	100+	5
			15	I	64	5
			20	I	100+	8
		Becomes slightly silty.	25	I	67	8
			30	I	30	7
	SM	Black, silty SAND, fine grained, wet, loose.	35	I	4	29
			40 ▼	I	9	41
	ML	Gray sandy SILT with some organics, wet, soft to stiff.	45	I	16	44
			50	I	3	45
	SM	Black, very silty SAND, fine grained, wet, medium dense to dense.	55	I	36	27
			60	I	55	27
			65			

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BORING LOG

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Proj. No. 1630 | Date 10-91 | Figure A-18

BORING NO. 17

Logged By DBG

Date 7-1-91

ELEV. 65±

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Black, very silty SAND, fine to very fine grained, wet, dense.	70	I	30	29
			75	I	52	27
	ML	Gray, sandy SILT, wet, stiff.	80	I	17	40
	SP	Black, slightly silty SAND, fine to medium grained, wet, dense.	85	I	51	18
			90	I	48	16
			95	I	60	22
	SW	Black gravelly SAND, fine to coarse grained, wet, dense.		I	33	14

Boring complete at depth 99 feet.
Groundwater noted at 40 feet.

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BORING LOG

STATE ROUTE 167

KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-91	Figure A-18

BORING NO. 18

Logged By DBG

Date 7-2-91

ELEV. 56±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Gray-tan, slightly gravelly, silty SAND, fine to medium grained, moist, loose (FILL)	5	I	8	9
			10	I	18	15
			15	I	16	16
				I	8	23
	ML	Grades to sandy, clayey gravelly SILT. (FILL) 30	20	I	26	15
	SM	Black silty SAND, fine grained, wet, very loose. (sandy SILT lenses) 20	25, 30	I	2	39
			35	I	4	29
	ML	Gray sandy SILT with some organics, wet, stiff. 15	40	I	21	74
	SM	Black, silty SAND, fine grained, wet, medium dense to dense.	45	I	26	25
			50	I	43	26
			55	I	40	28
			60	I	47	25
			65	I	37	25

BORING CONTINUED ON NEXT PAGE

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BORING LOG
STATE ROUTE 167
KING COUNTY, WASHINGTON

Proj. No. 1630 | Date 10-91 | Figure A-19

BORING NO. 18

Logged By DBG

Date 7-2-91

ELEV. 56±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)	
	SM	Black silty SAND, fine grained, wet, dense. -15	70	I	41	27	
	ML	Gray SILT with some organics, wet, stiff.	75	I	13	42	
		-23	80	II	40	45	
	SP	Black, slightly silty SAND fine to medium grained, wet, dense.	85	I	81	20	
			90	I	77	16	
			95	I	70	26	
				I	100+	20	

Boring completed at depth 99 feet.
Groundwater noted at 27 feet.

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BORING LOG
STATE ROUTE 167
KING COUNTY, WASHINGTON

Proj. No. 1630 | Date 10-91 | Figure A-19

BORING NO. 19

Logged By DBG

Date 7-8-91

ELEV. 30±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)	
	SM	Brown, gravelly SAND. (FILL)					
	ML	Gray SILT, wet, soft.	5	I	5	32	
	SP	Black slightly silty, SAND, fine grained, wet medium dense.	10	I	18	31	
			15	I	26	32	
			20	I	84+	27	
			25	I	21	29	
			30	I	29	29	
	ML	Gray sandy SILT, wet, stiff.	35	I	12	45	
		Becomes clayey and soft.		I	9	36	
	GM	Black, silty, sandy GRAVEL, wet, dense.	40				
		Becomes less silty.	45	I	64	10	
	SM	Brown silty SAND, fine to medium grained, wet, dense to very dense.	50	I	87+	20	
			55	I	92	17	
	ML	Gray, clayey SILT/SILT STONE, very hard.		I	80+	35	

Boring completed at depth 59 feet.
Groundwater noted at 8 feet.

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BORING LOG
STATE ROUTE 167
KING COUNTY, WASHINGTON

Proj. No. 1630	Date 10-91	Figure A-20

BORING NO. 20

Logged By DBG

Date 7-8-91

ELEV. 96±

Graph	USCS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)
	SM	Gray, slightly gravelly, silty SAND, fine to medium grained, moist, dense. (FILL)	5	I	36	17
			10	I	29	12
			15	I	51	13
			20	I	40	15
			25	I	25	22
			30	I	22	16
				I	94+	14
	GW	Grades to fine to coarse sandy gravel, wet. (FILL)	35			
			40	I	27	12
	ML	Gray, slightly sandy SILT, wet, stiff.	45	I	12	38
	SM	Black, silty SAND, fine to medium grained, wet, loose.	50	I	13	23
	SP	Clean SAND lenses.	55	I	6	46
			60	I	11	23
		Becomes fine to coarse grained and dense.	65	I	62	9

BORING CONTINUED ON NEXT PAGE

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BORING LOG
STATE ROUTE 167
KING COUNTY, WASHINGTON

Proj. No. 1630 | Date 10-91 | Figure A-21

BORING NO. 20

Logged By DBG

Date 7-8-91

ELEV. 96±

Graph	US CS	Soil Description	Depth (ft.)	Sample	(N) Blows Ft.	W (%)	
	SM	Black, silty, gravelly SAND, fine to coarse grained, wet, dense.	70	I	94	20	
		Becomes very gravelly.	75	I	23	3	
			80	I	100+	15	
			85	I	100+	5	
			90	I	55	13	
			95	I	100+	13	
	SW	Becomes slightly silty		I	69	10	

Boring completed at depth 99 feet.
Groundwater noted at 33 feet.

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BORING LOG

STATE ROUTE 167

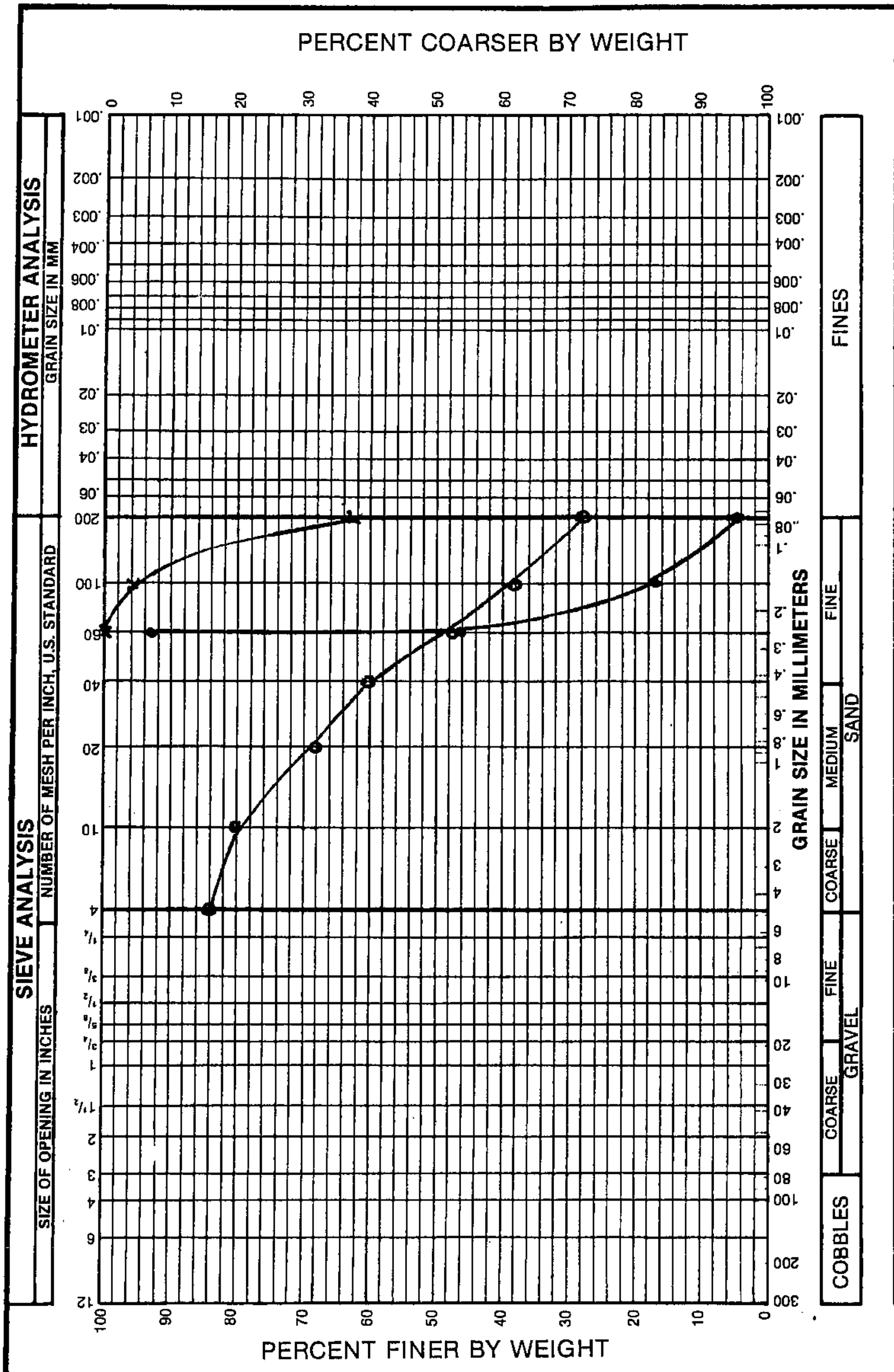
KING COUNTY, WASHINGTON

Proj. No. 1630 | Date 10-91 | Figure A-21

APPENDIX B

LABORATORY TESTING

We performed various laboratory tests on selected samples of soils recovered from the test borings. The tests were performed to determine vertical, physical and mechanical properties of the subsurface soils. Moisture contents were determined for all samples obtained from the borings and are reported on the boring logs at the appropriate depth. Grain size and hydrometer analyses were performed on selected samples to determine the particle size distribution. The results of these tests are shown on Figures B-1 through B-22. Consolidation tests were performed on selected samples and the results are shown on Figures B-23 through B-26.



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
✕	B-1	28	ML	sandy SILT	34		
●	B-1	48	SP	SAND with silt	27		
○	B-2	33	SM	gravelly silty SAND	8		

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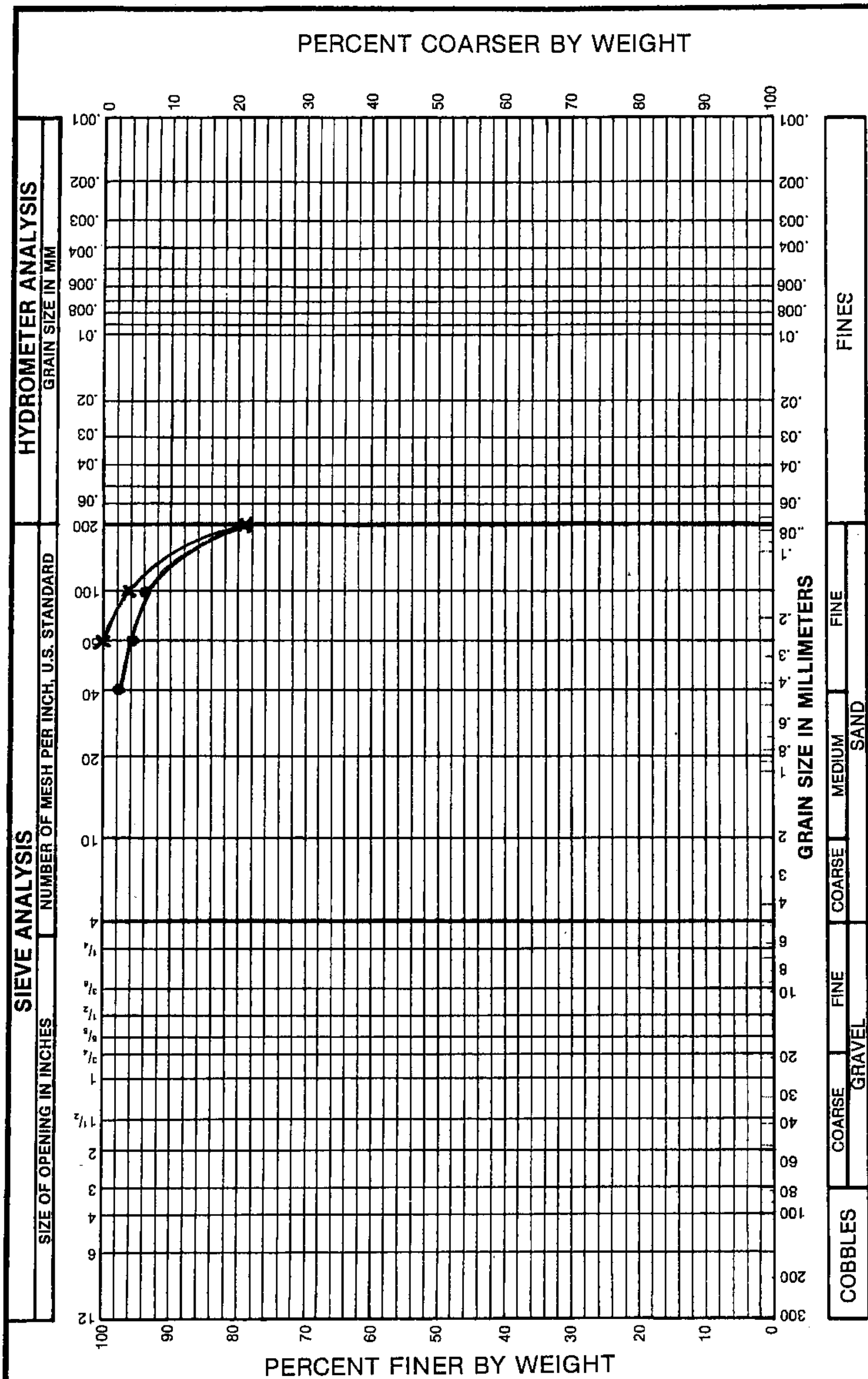
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630 | Date 10-91 | Figure B-1



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
—x—	B-2	48	ML	sandy SILT	33		
—•—	B-2	58	ML	sandy SILT, with organics	56		

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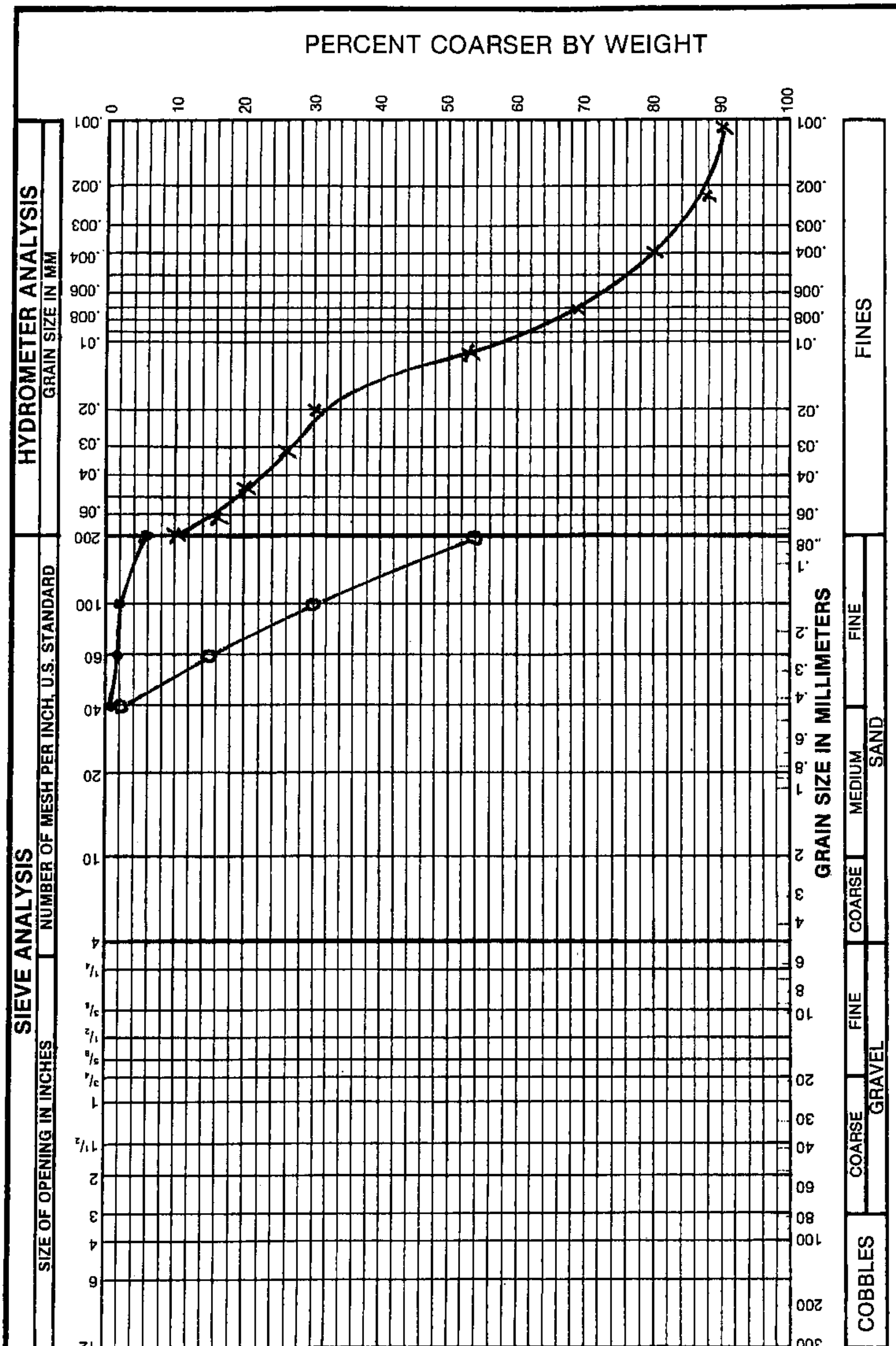
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630 | Date 10-91 | Figure B-2



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
x	B-3	28	ML	SILT	44		
•	B-3	38	ML	SILT	33		
o	B-3	52	SM	silty SAND	25		

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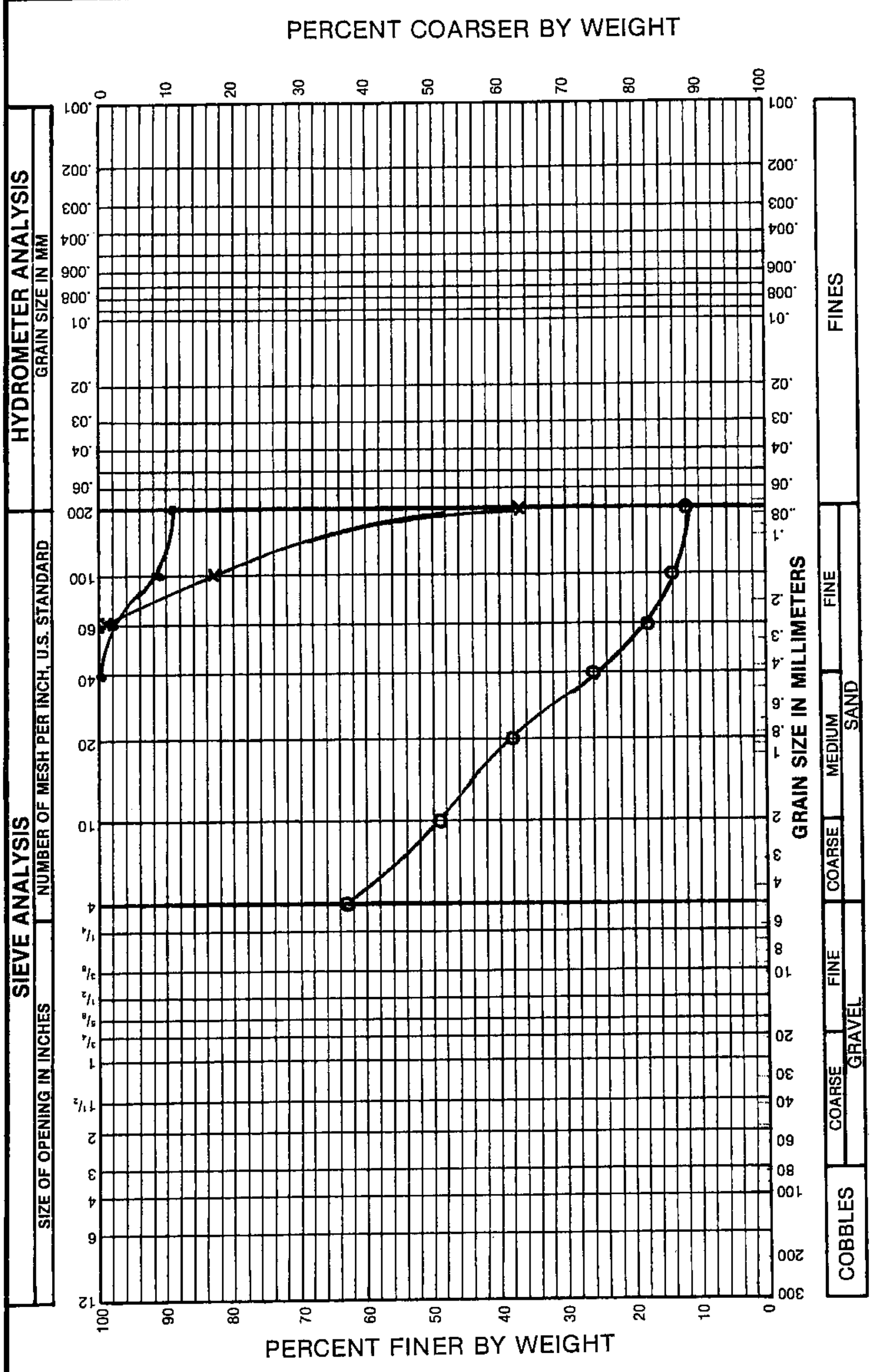
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630	Date 10-91	Figure B-3



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
—x—	B-4	48	SM	silty SAND	23		
—•—	B-4	58	ML	sandy SILT	57		
—o—	B-5	18	SM	silty gravelly SAND	11		

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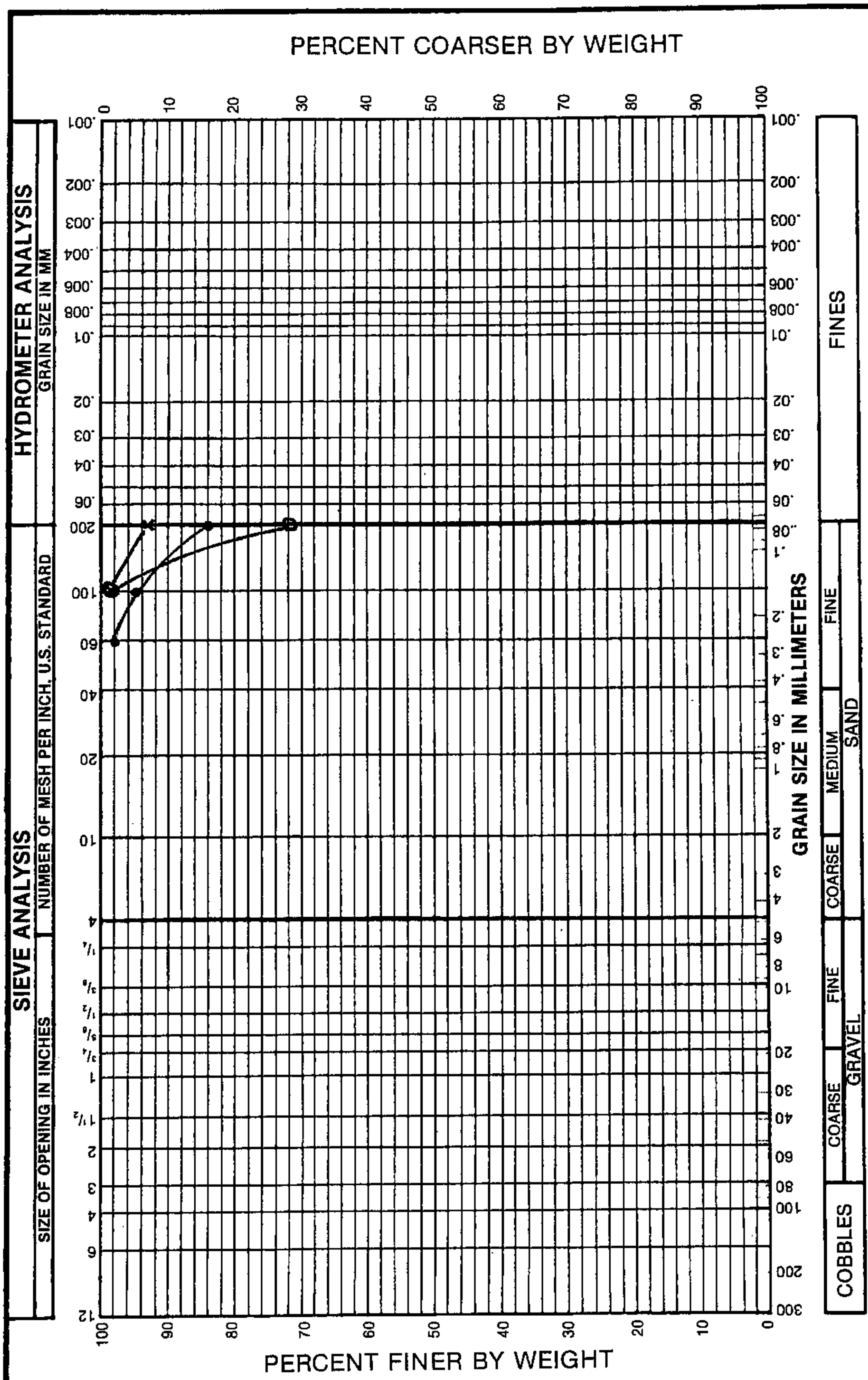
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630	Date 10-91	Figure B-4



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
—x—	B-5	28	ML	SILT with clay	37		
—●—	B-5	43	ML	sandy SILT	43		
—o—	B-6	28	ML	sandy SILT	29		

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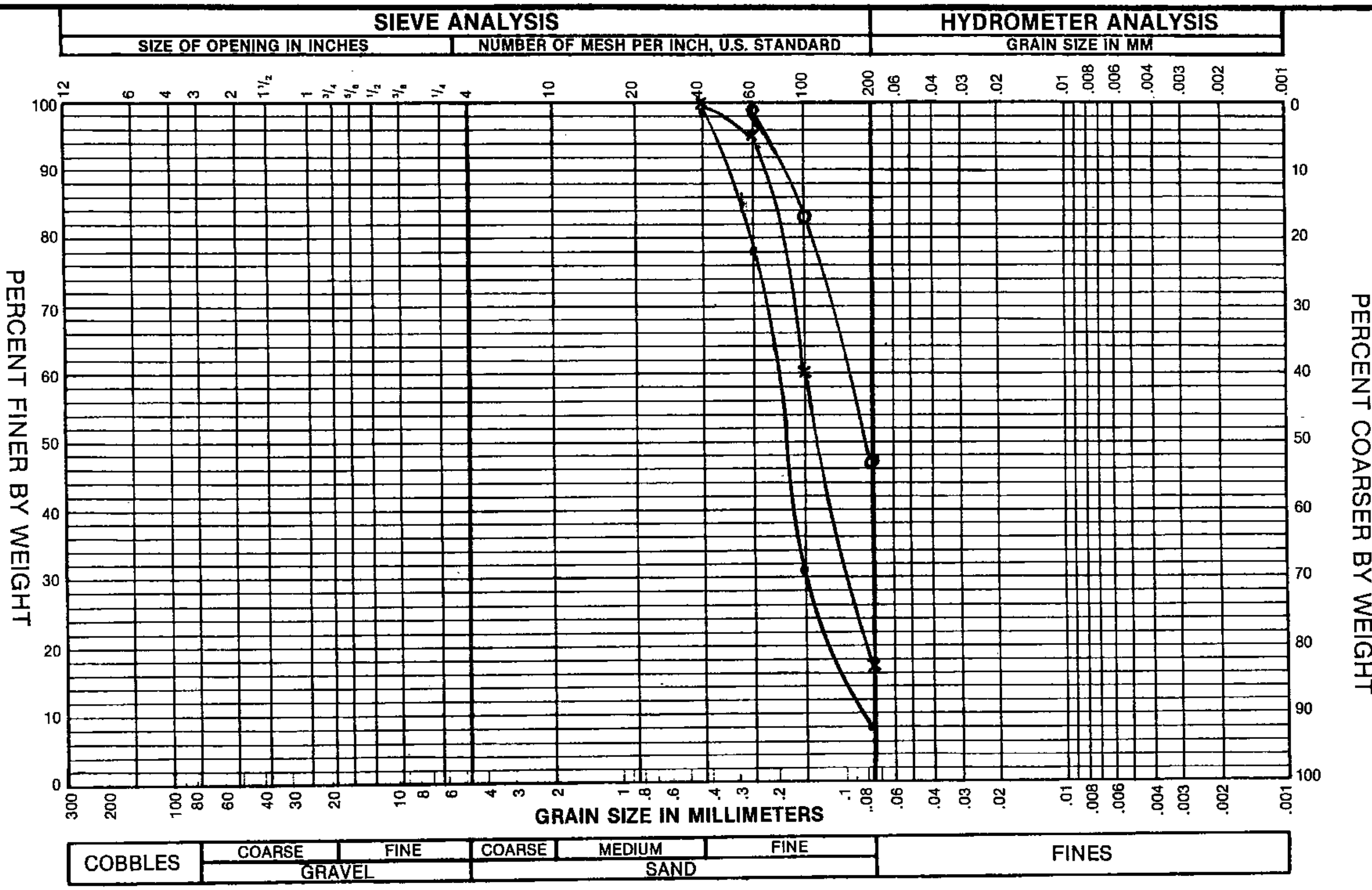
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630	Date 10-91	Figure B-5



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
—x—	B-6	38	SM	silty SAND	39		
—•—	B-6	43	SP	SAND with silt	31		
—o—	B-7	28	SM	silty SAND	31		

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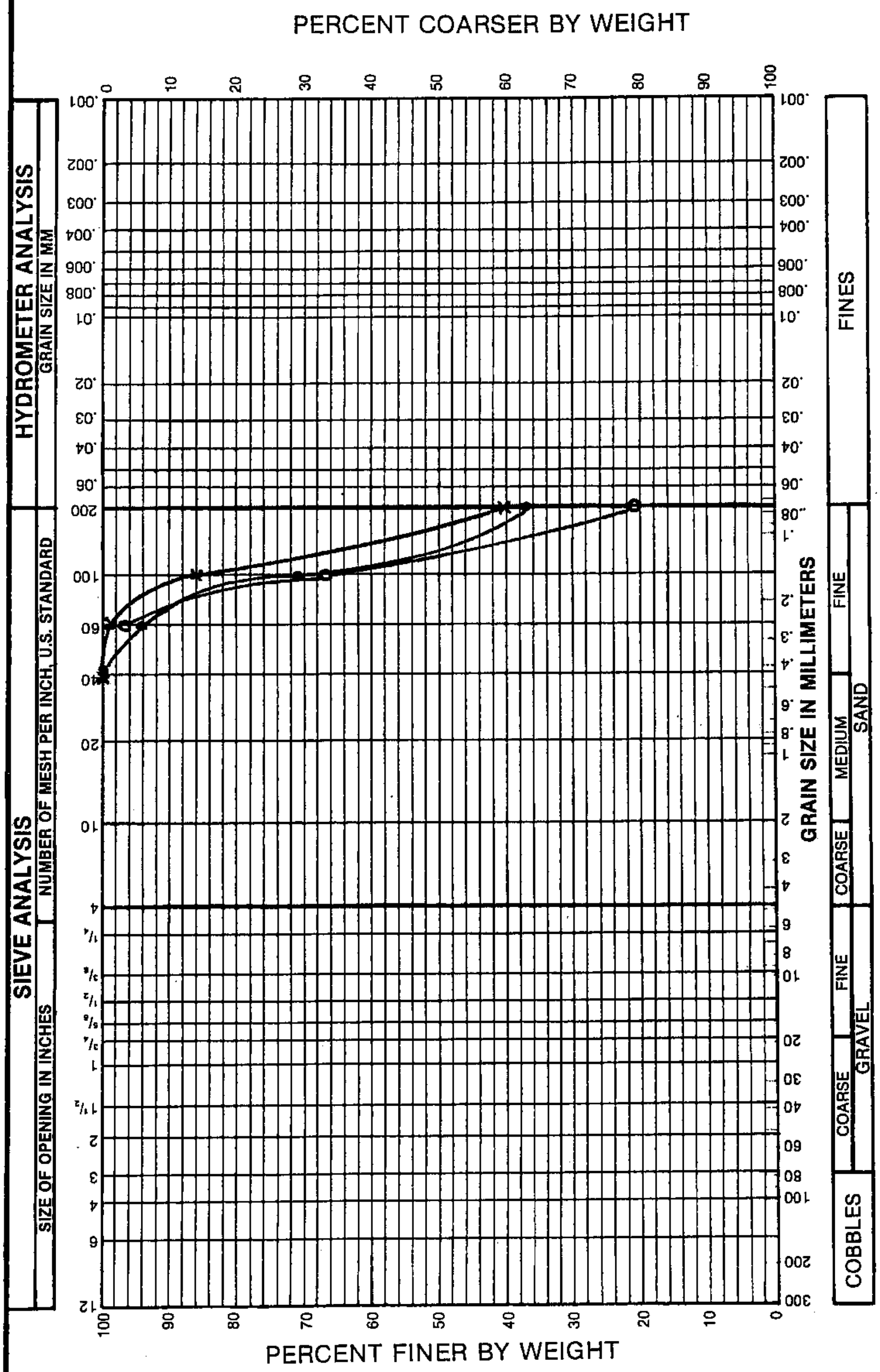
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630 | Date 10-91 | Figure B-6



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
—o—	B-8	28	SM	silty SAND	27		
—x—	B-7	33	SM	silty SAND	36		
—•—	B-7	48	SM	silty SAND	31		

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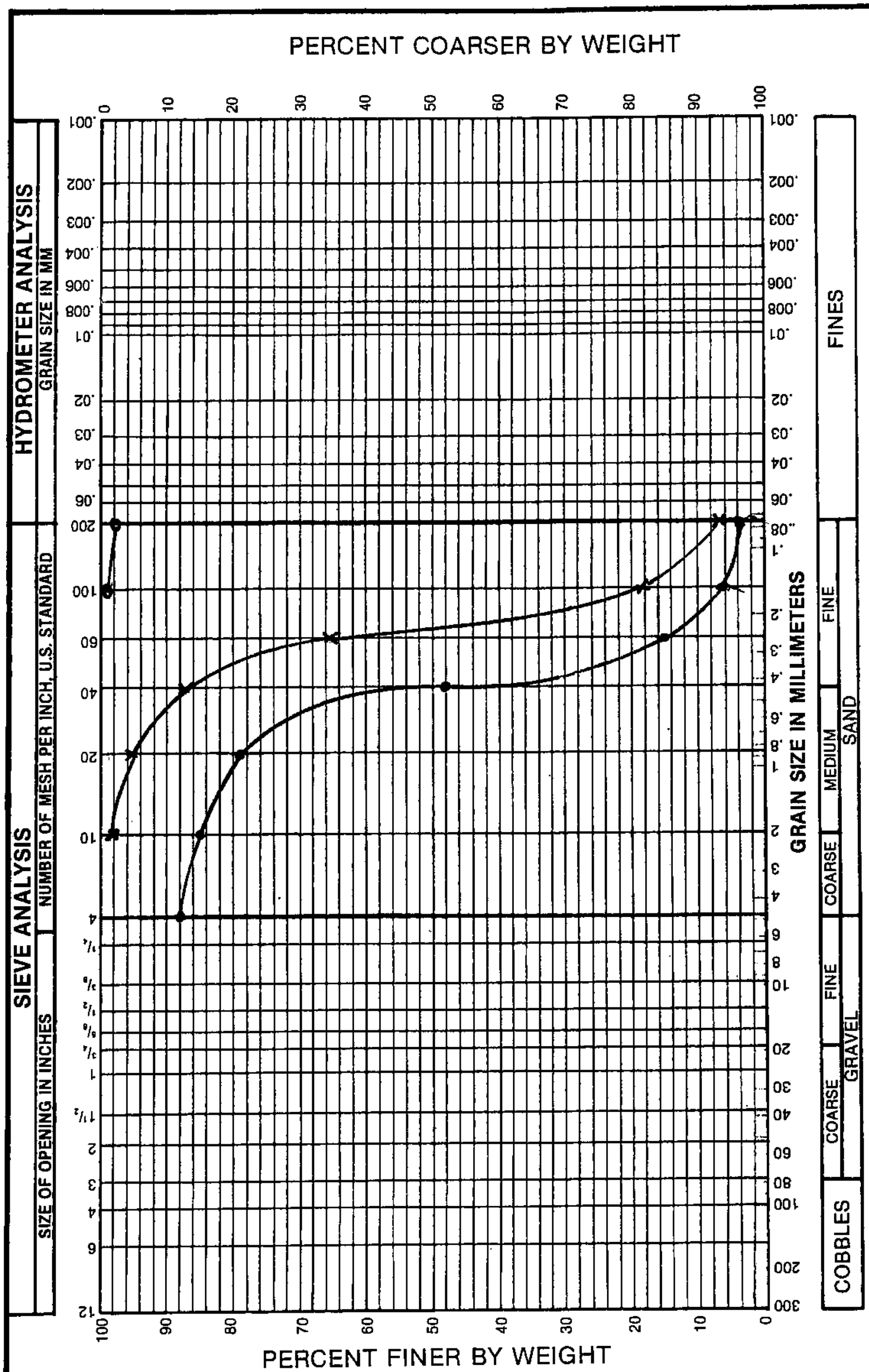
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630	Date 10-91	Figure B-7



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
—✱—	B-8	33	SP/SM	SAND with silt	21		
—●—	B-8	48	SP	SAND	30		
—○—	B-9	43	ML	SILT with clay	44		

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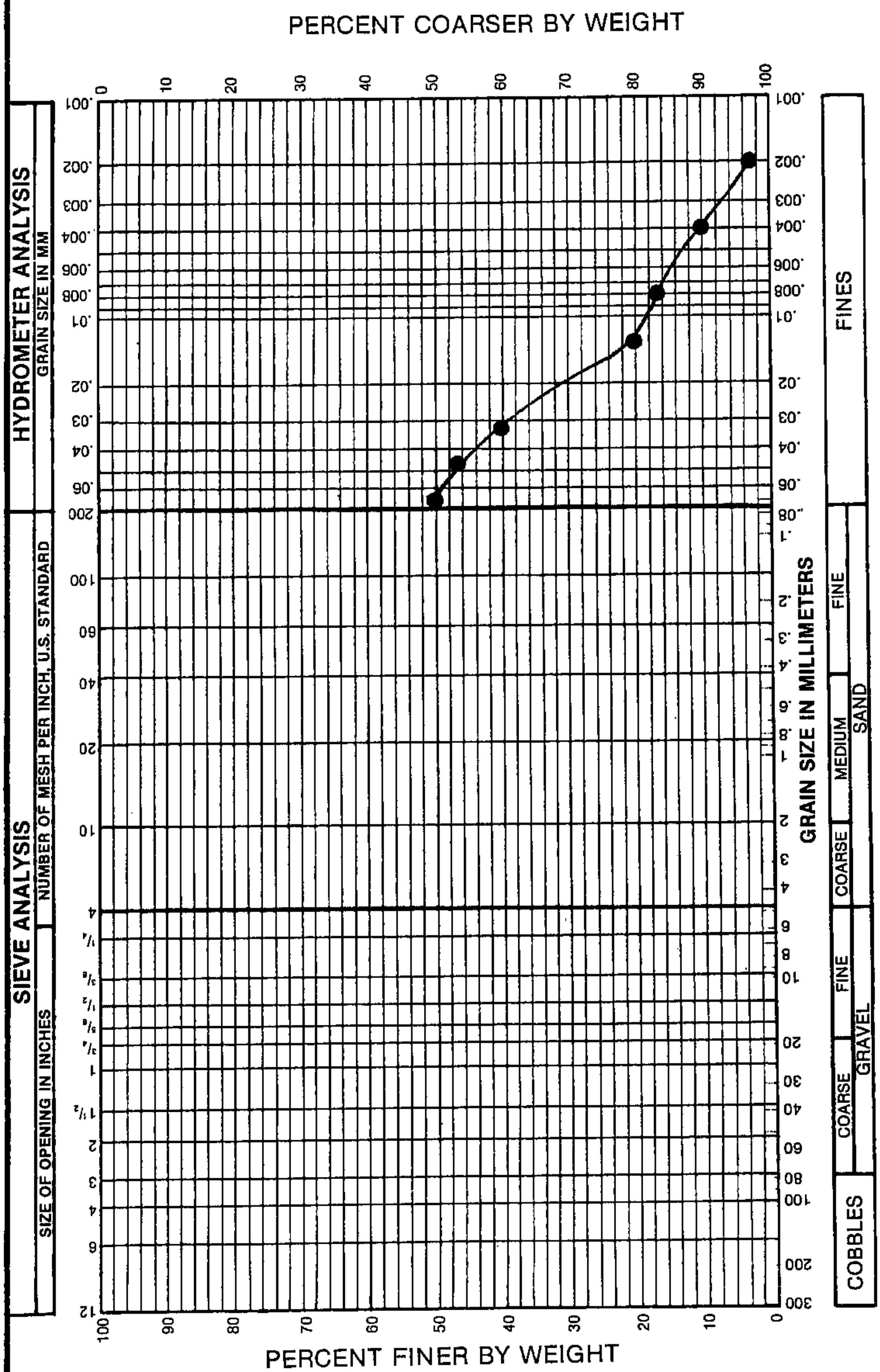
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630	Date 10-91	Figure B-8



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
●	B-9	42.5	ML	SILT with sand and clay	43.0	-	-

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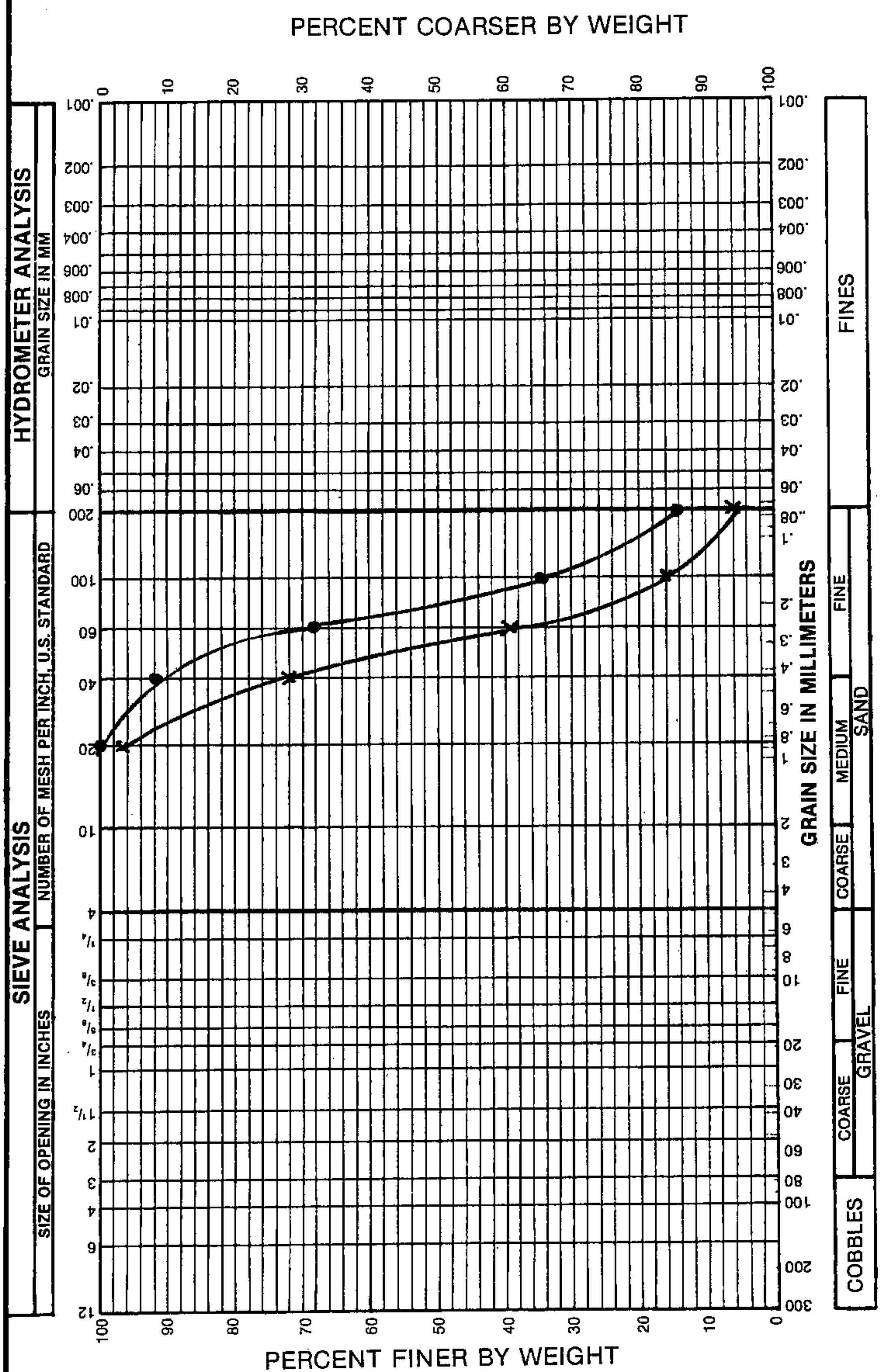
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630	Date 10-91	Figure B-9



Key	Boring or Test Pit.	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
x	B-9	58	SP	SAND with silt	22		
●	B-9	63	SM	silty SAND	26		

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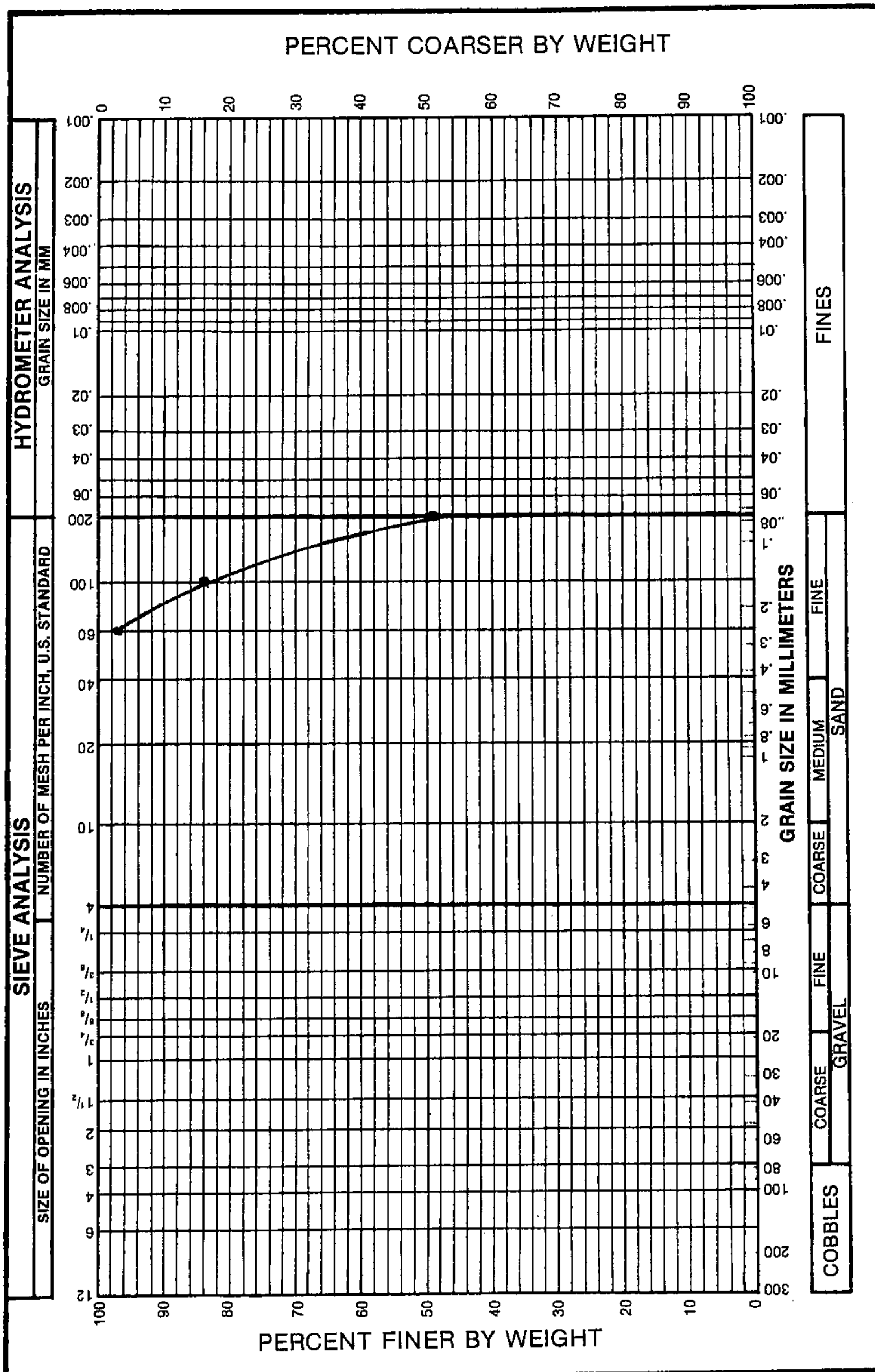
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630	Date 10-91	Figure B-10



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
—●—	B-10	43	SM/ML	silty SAND to sandy SILT	33		

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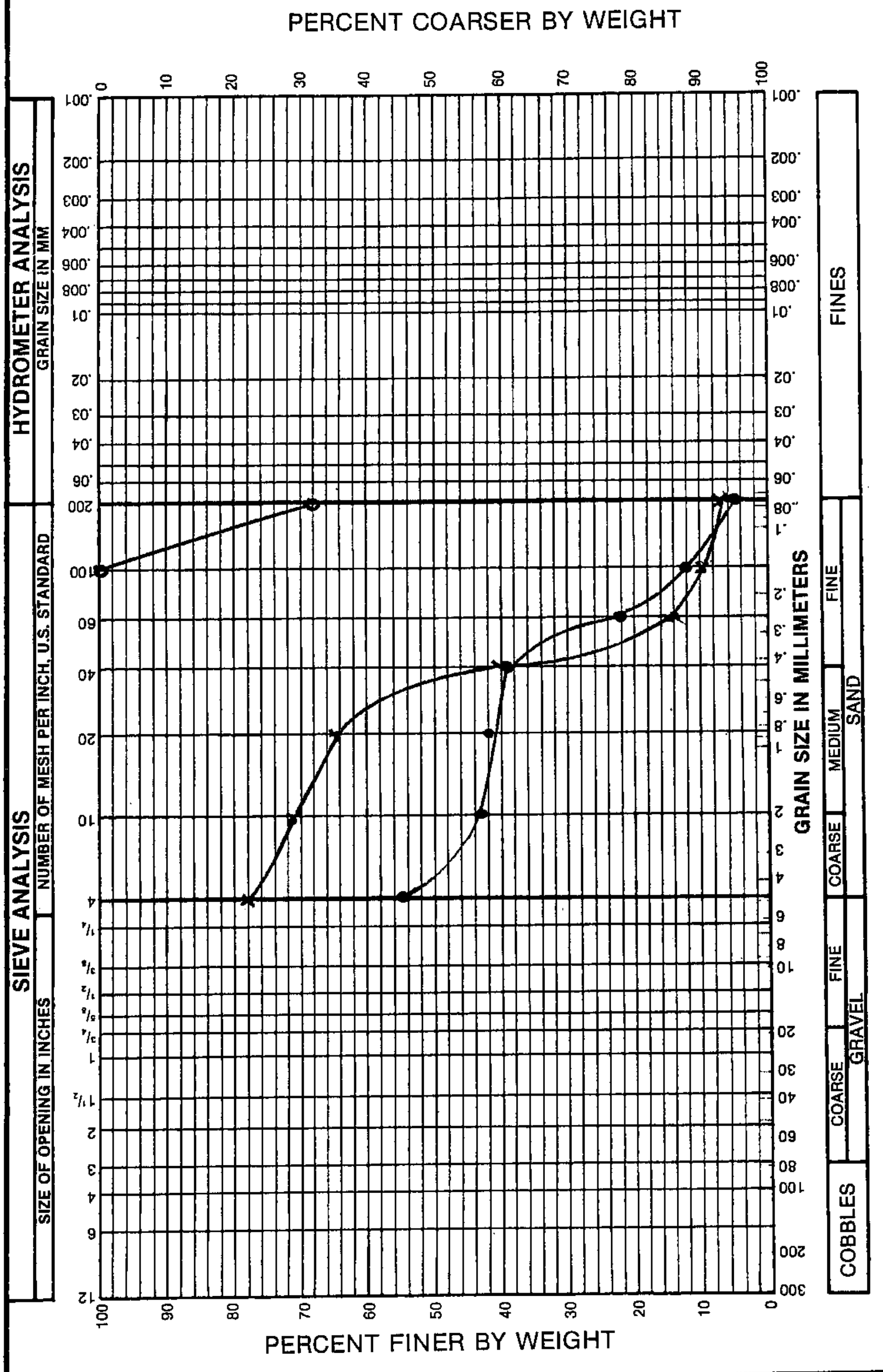
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630	Date 10-91	Figure B-11



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
—x—	B-10	53	SM/SP	gravelly SAND with silty with wood	38		
—•—	B-10	63	SM/SP	gravelly SAND with silt	19		
—o—	B-11	23	ML	sandy SILT	31		

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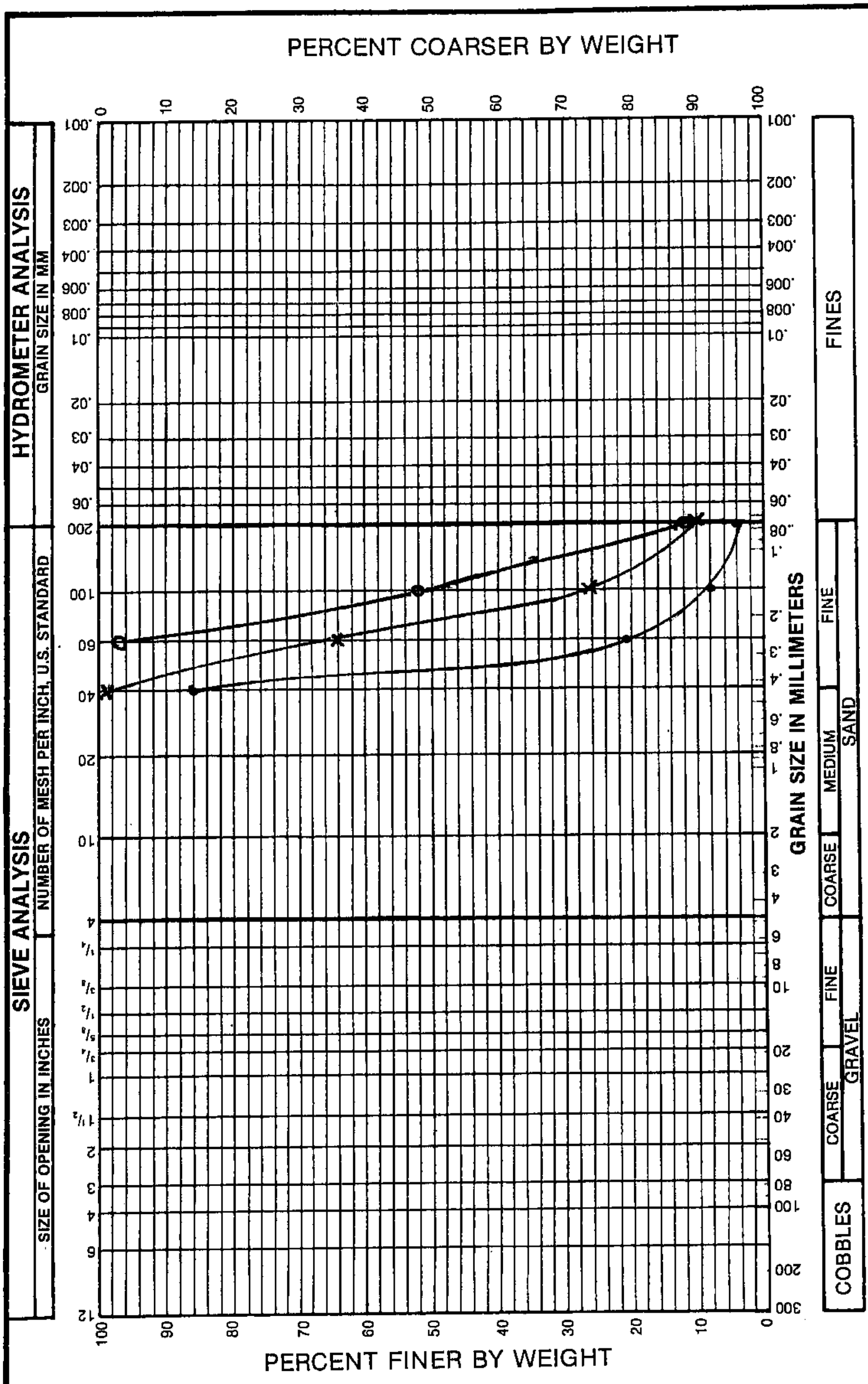
GRAIN SIZE ANALYSIS
State Route 167
King County, Washington

Proj. No. 1630 | Date 10-91 | Figure B-12



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
—x—	B-11	28	SM/SP	SAND with silt	13		
—●—	B-11	33	SP	SAND	24		
—o—	B-12	33	SM/SP	SAND with silt	33		

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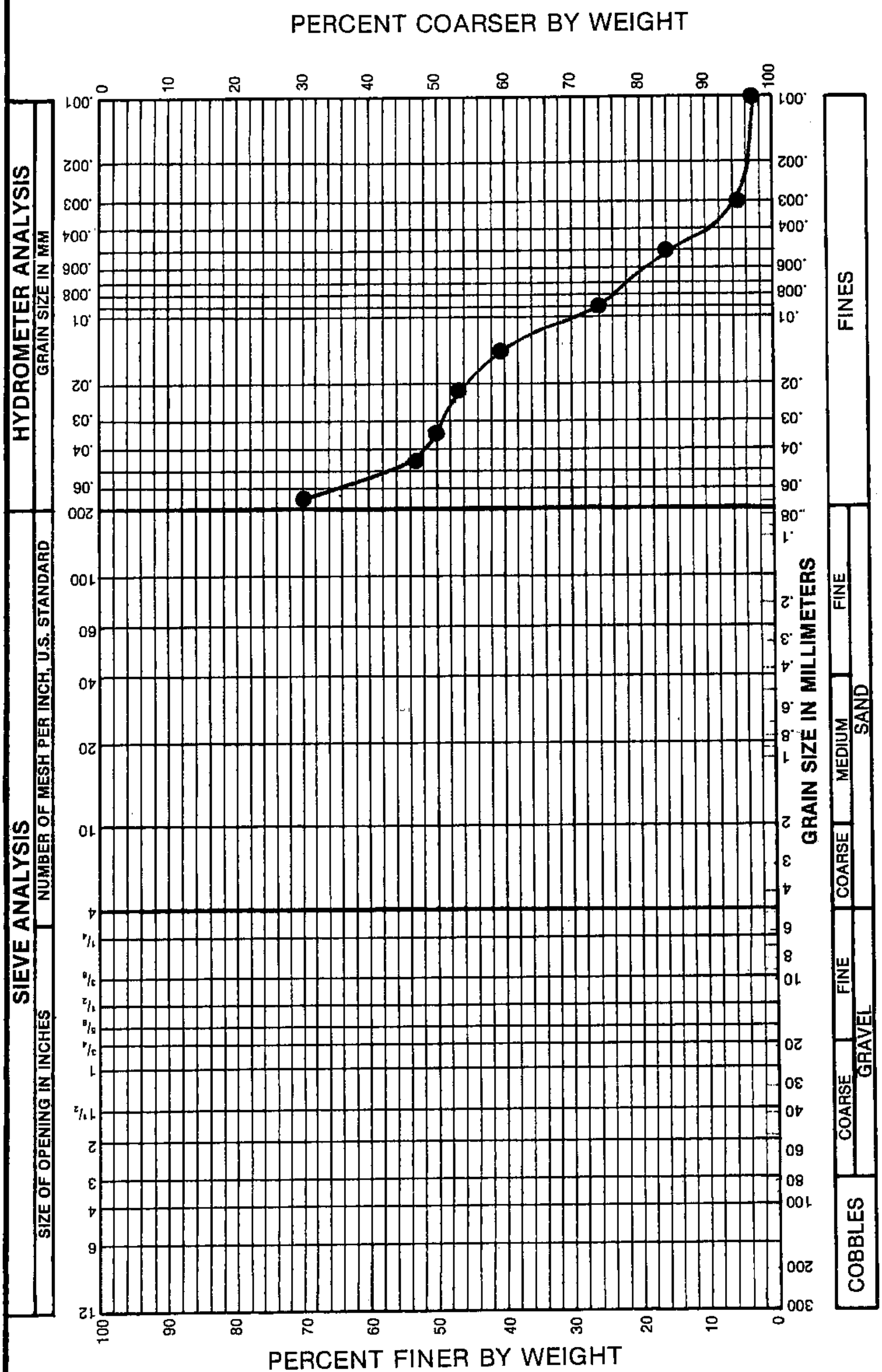
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630	Date 10/91	Figure B-13



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
●—	B-12	42.5	ML	SILT with sand, clay small wood fragments	53.8	-	-

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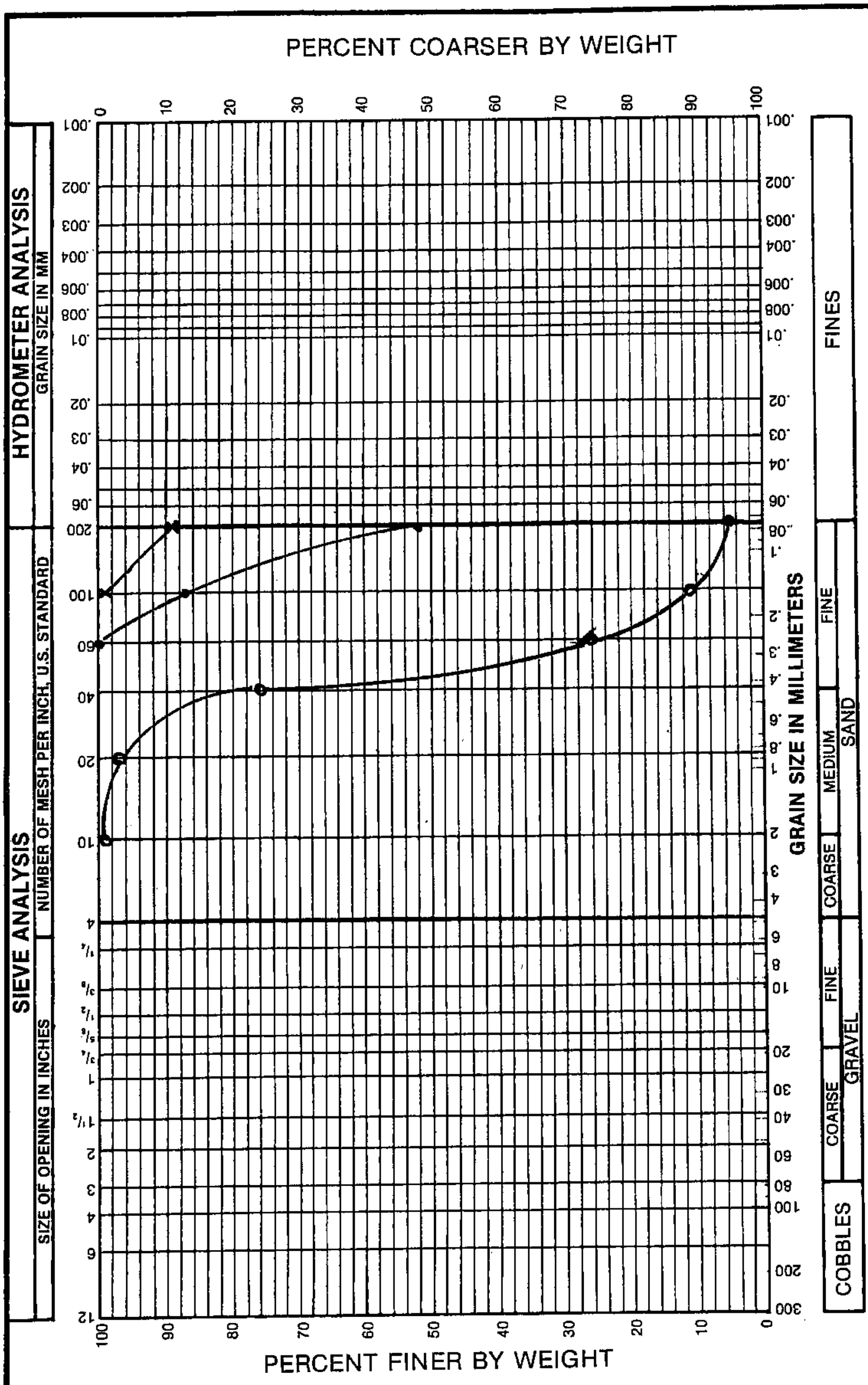
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630	Date 10-91	Figure B-14



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
—x—	B-12	38	ML	sandy SILT	35		
—•—	B-12	48	ML	sandy SILT	34		
—o—	B-13	28	SP	SAND	24		

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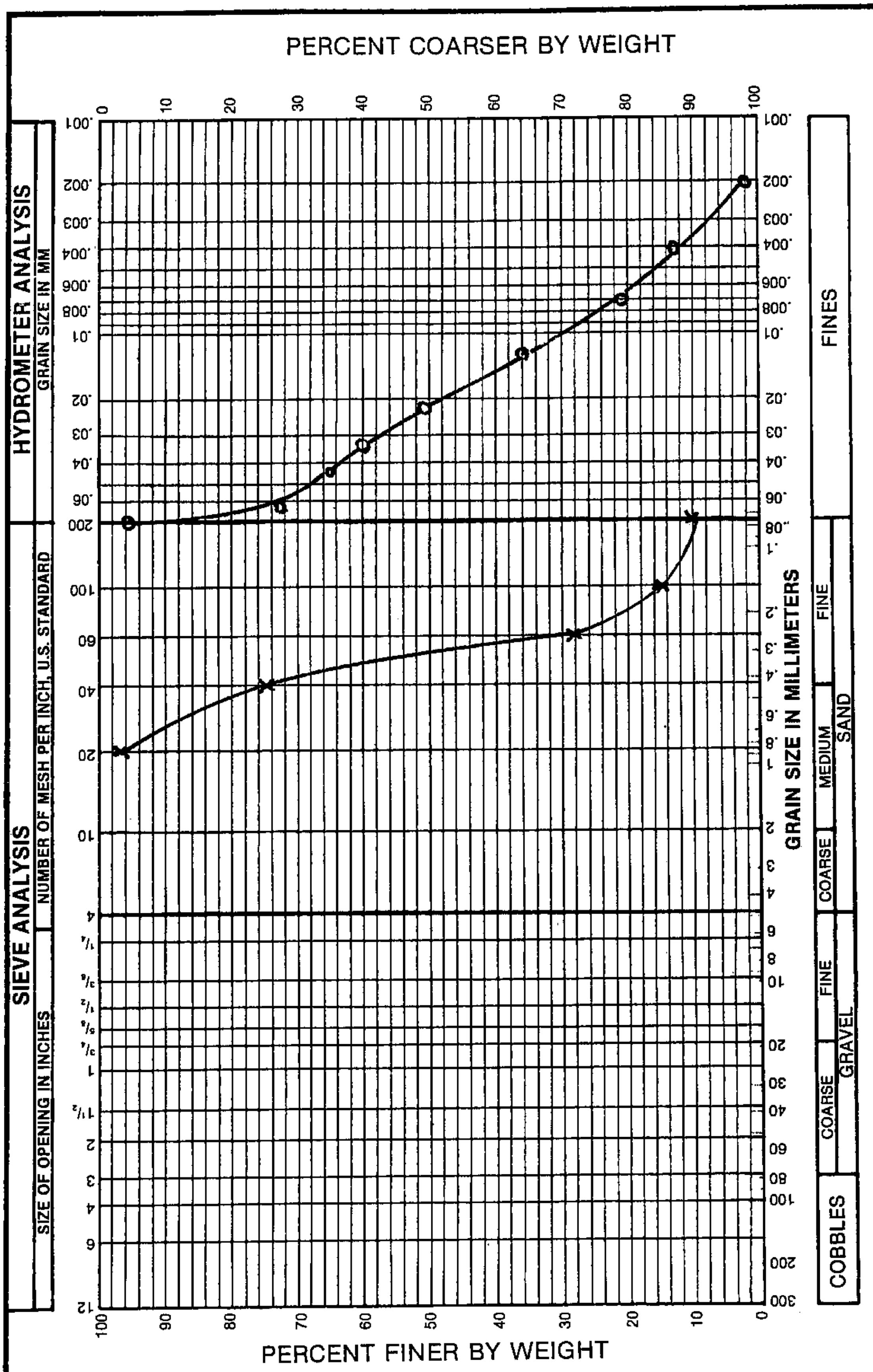
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630 | Date 10-91 | Figure B-15



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
—x—	B-13	38	SP/SM	SAND with silt	20		
—o—	B-15	58	ML	SILT	39		

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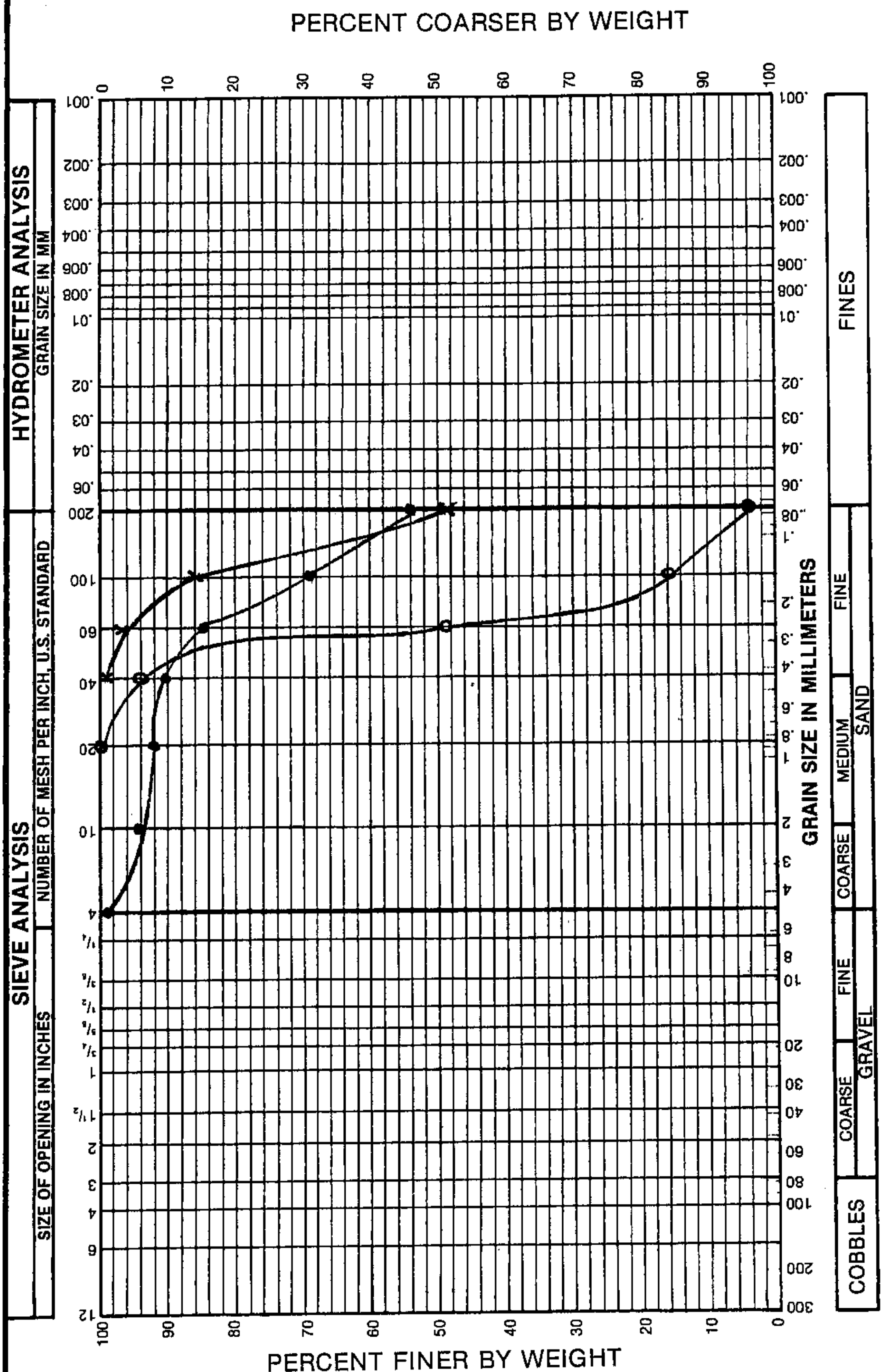
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630 | Date 10-91 | Figure B-16



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
—●—	B-14	33	ML	sandy SILT			
—x—	B-15	43	SM	silty SAND			
—o—	B-15	53	SP	SAND			

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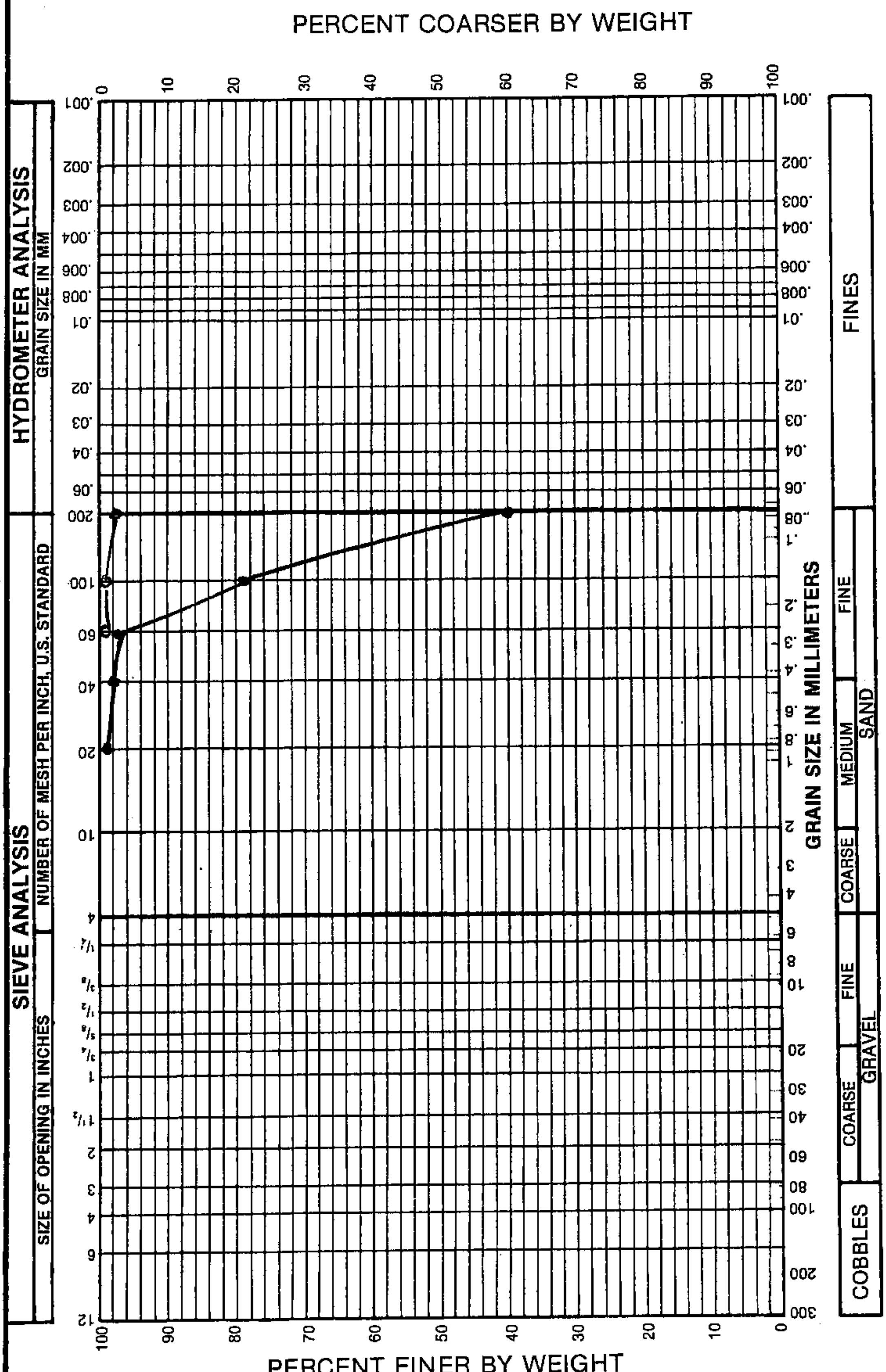
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630	Date 10-91	Figure B-17



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
—●—	B-16	28	SM	silty SAND	38		
—○—	B-16	33	ML	SILT with clay	40		

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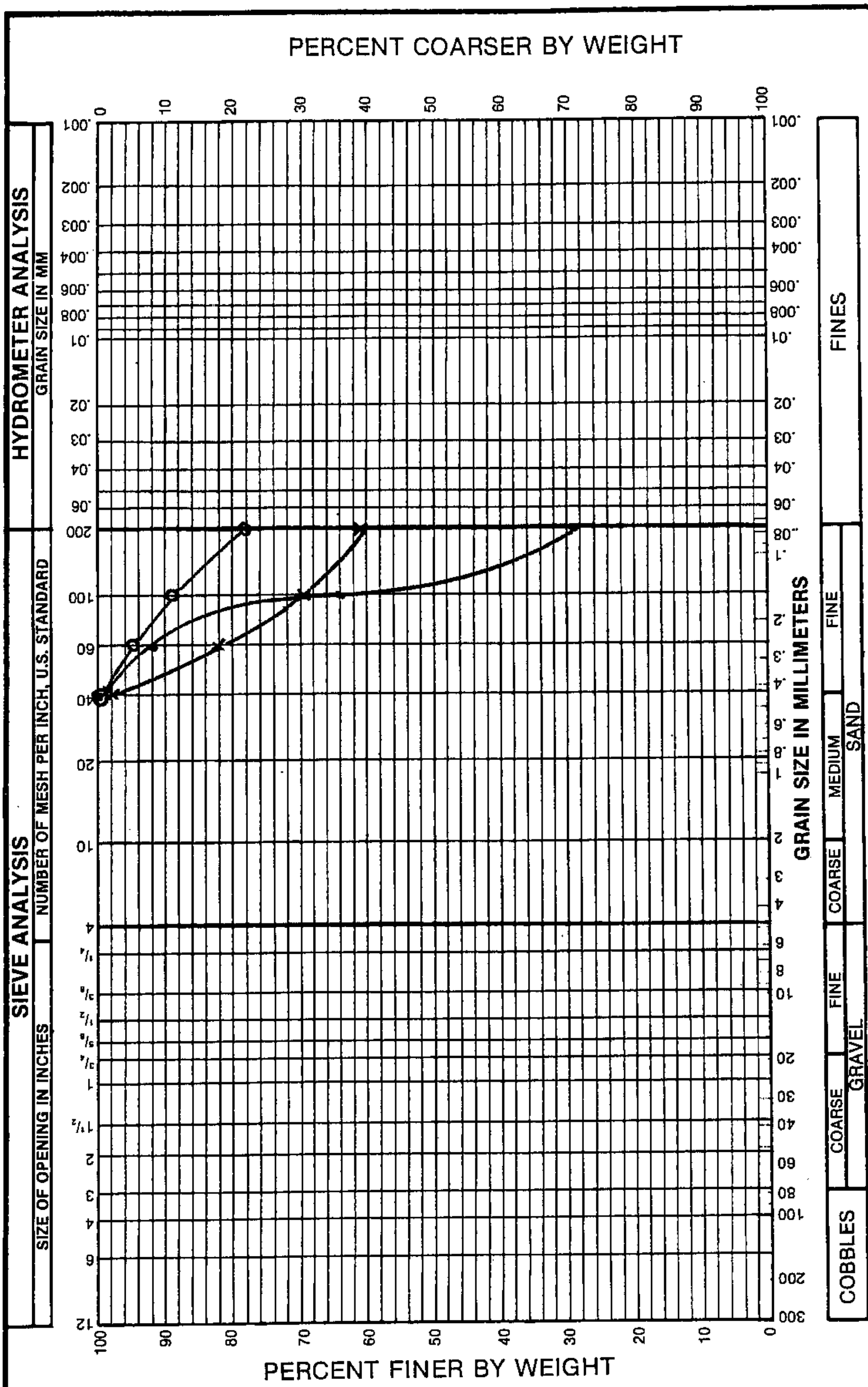
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630	Date 10-91	Figure B-18



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
—x—	B-16	43	ML	sandy SILT	38		
—•—	B-17	38	SM	silty SAND	29		
—o—	B-17	53	ML	sandy SILT	45		

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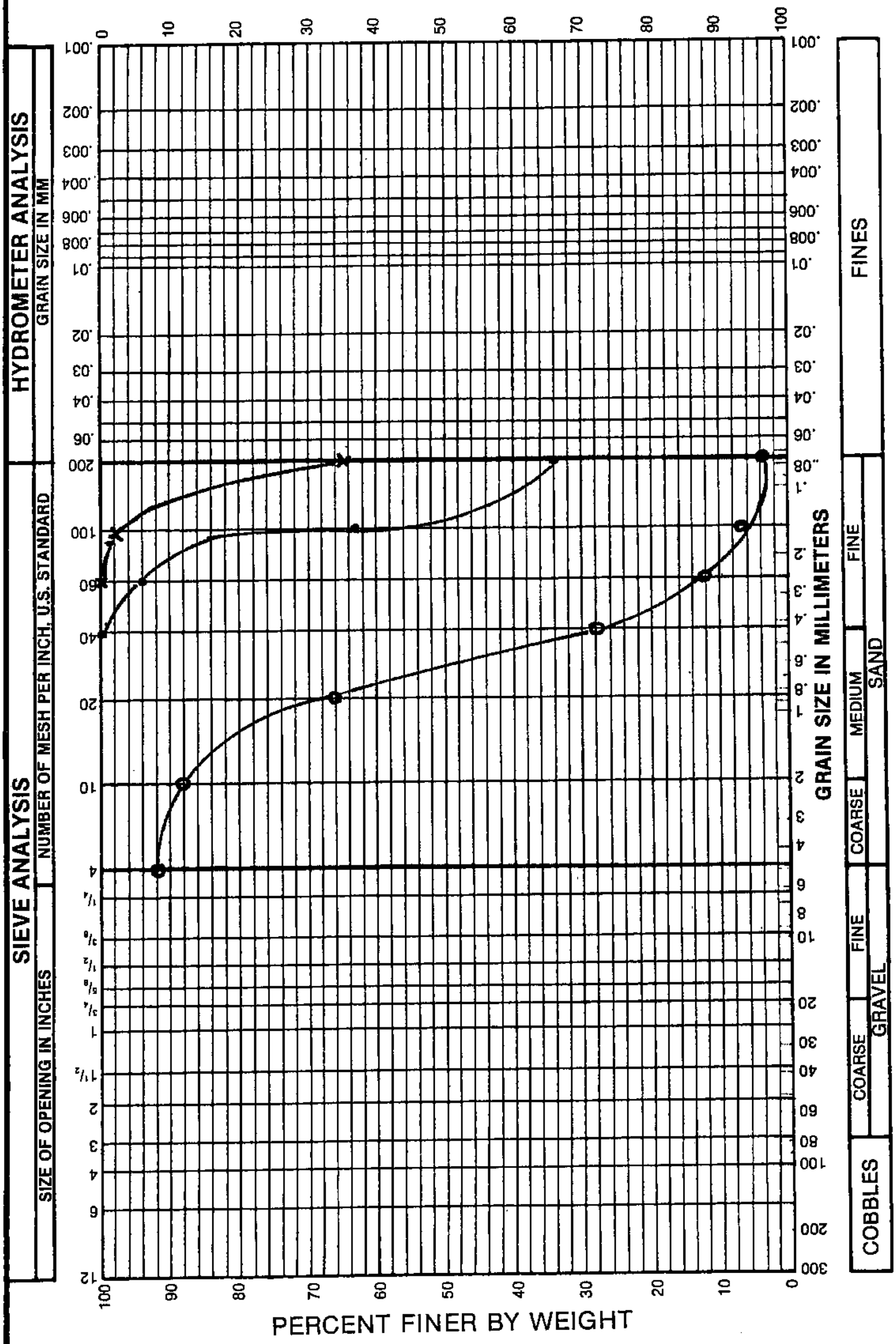
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630	Date 10-91	Figure B-19



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
	B-18	28	ML	sandy SILT	39		
	B-18	33	SM	silty SAND	29		
	B-19	23	SP	SAND with gravel	29		

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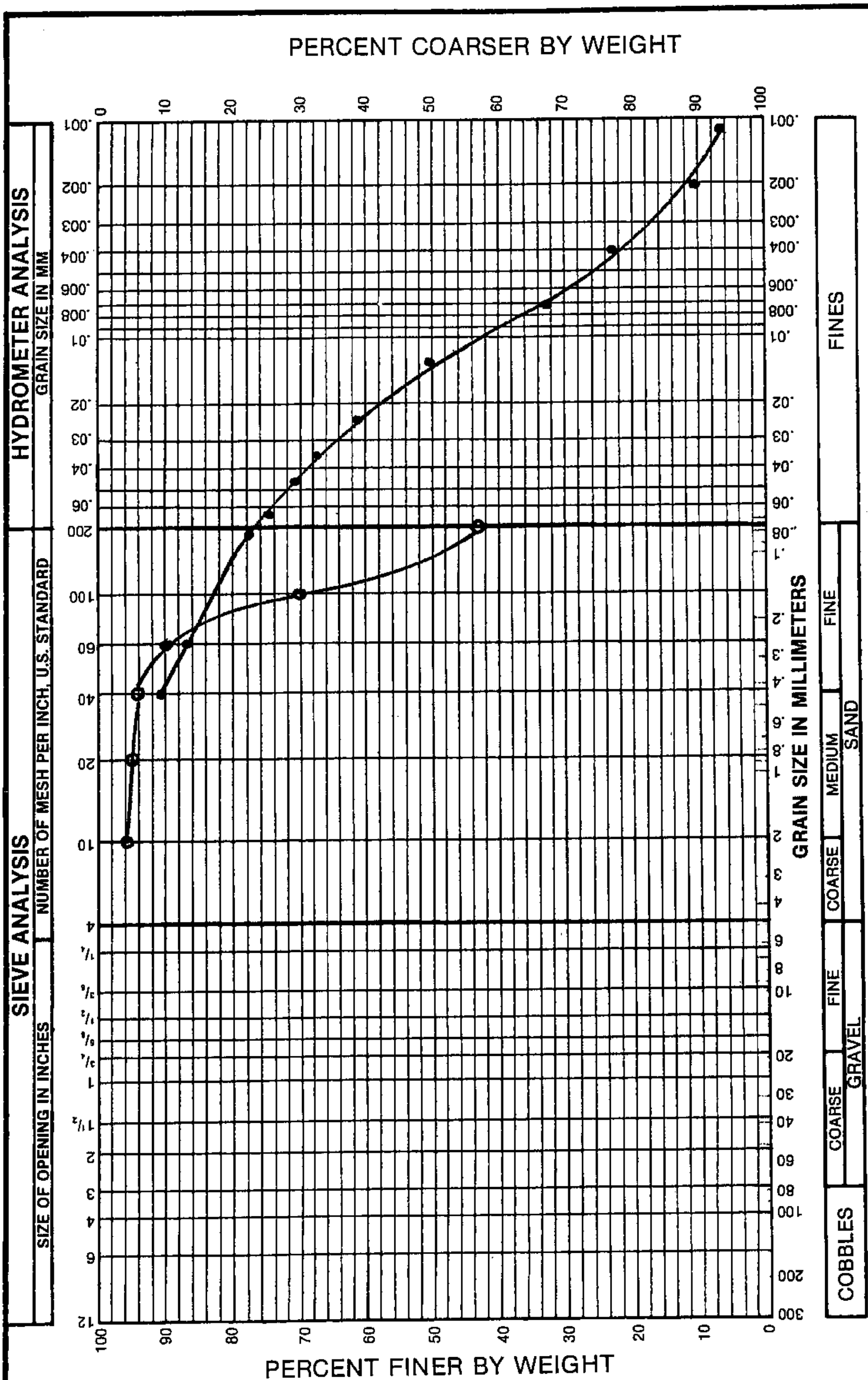
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630	Date 10-91	Figure B-20



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
—●—	B-19	38	ML	sandy SILT	36		
—○—	B-20	53	SM	silty SAND	46		

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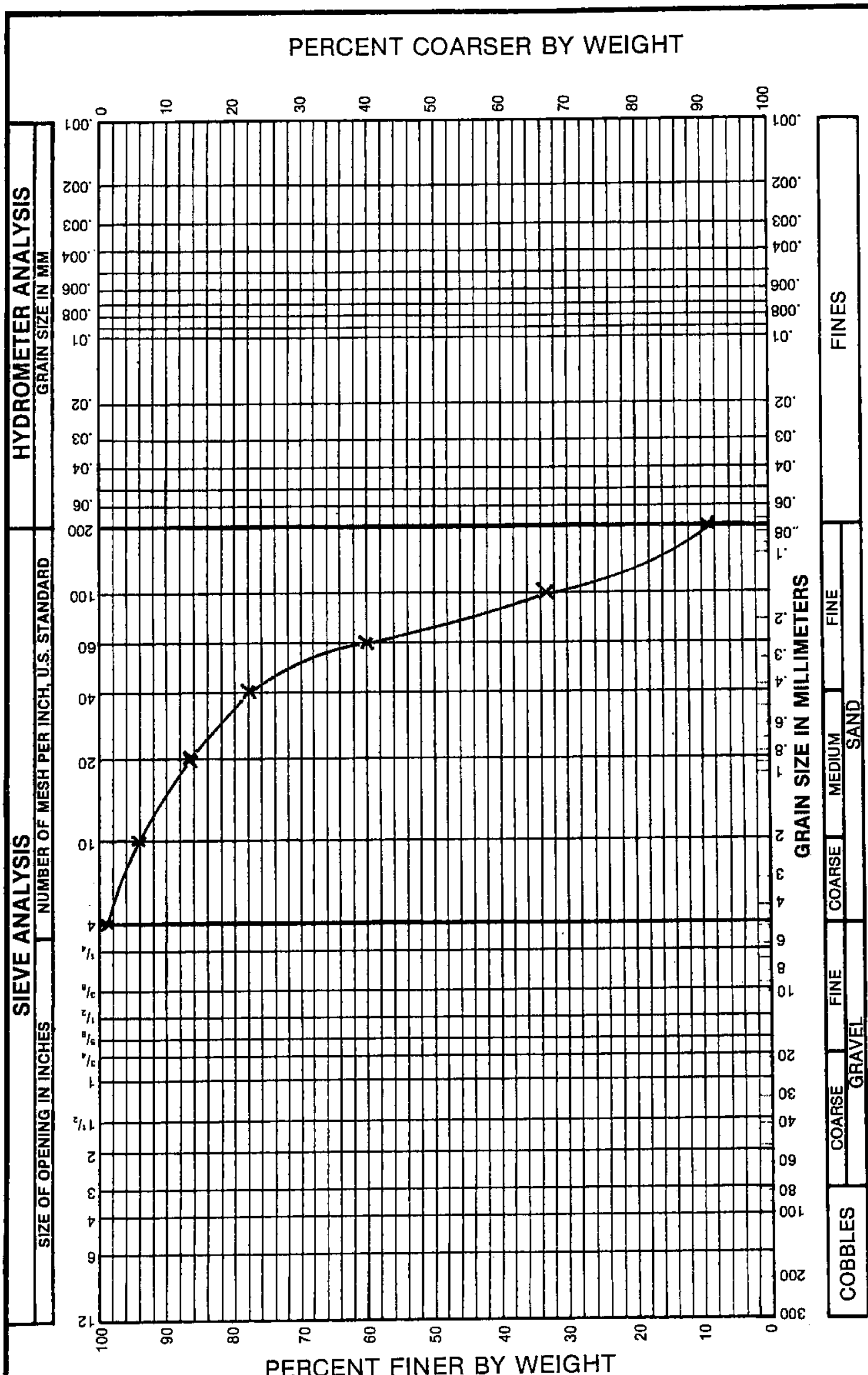
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630	Date 10-91	Figure B-21



Key	Boring or Test Pit	Depth (ft.)	USCS	Description	Moisture Content (%)	LL	PL
—✕—	B-20	58	SP/SM	SAND with silt	23		

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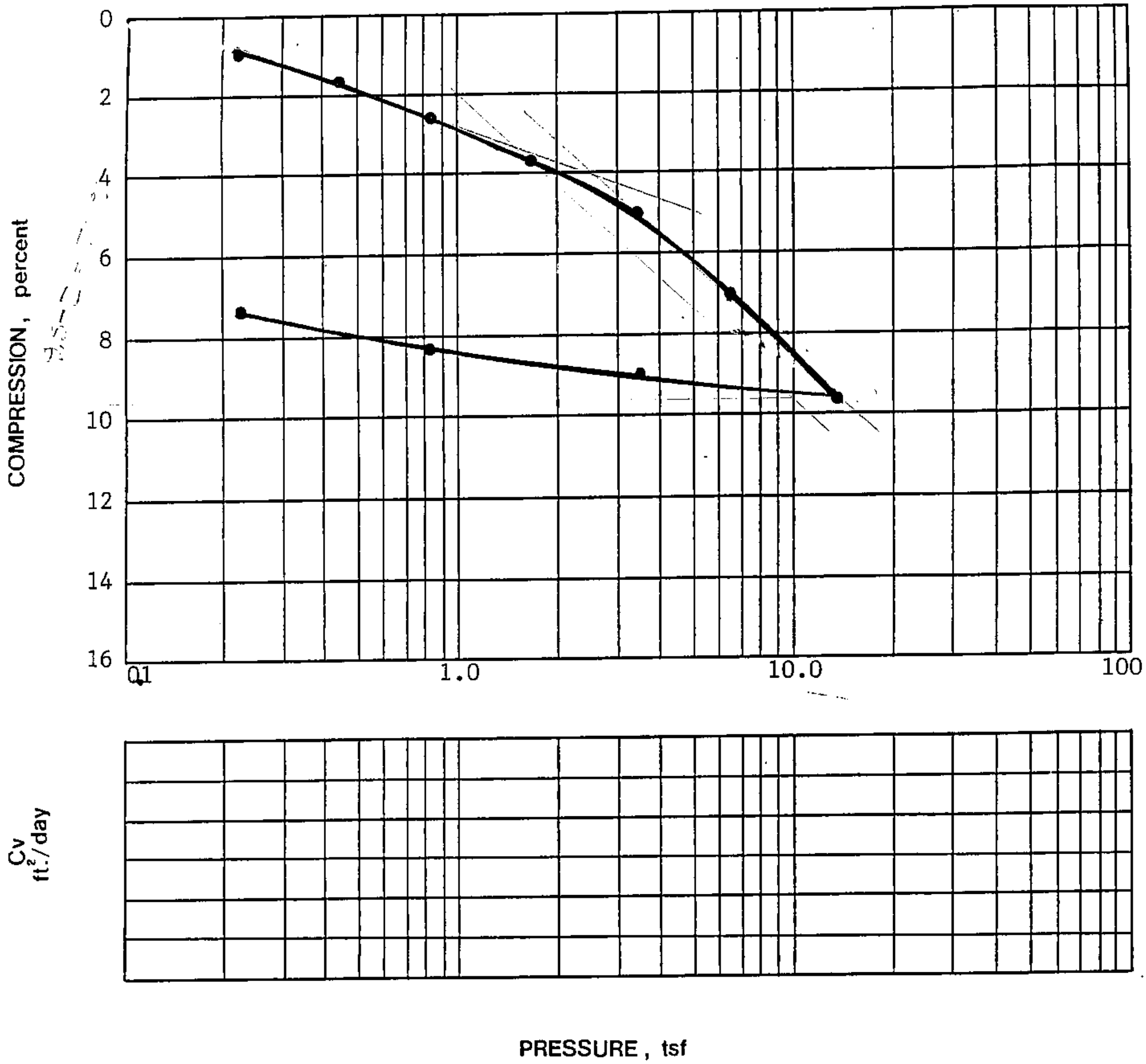
GRAIN SIZE ANALYSIS

State Route 167
King County, Washington

Proj. No. 1630	Date 10-91	Figure B-22



Key	Boring No.	Depth (ft.)	USCS	Soil Description	Liquid Limit %	Plastic Limit %	Plasticity Index %	Moisture Content, W % Before	Moisture Content, W % After	Dry Density (pcf)
—●—	B-10	42.5	ML	Sandy SILT with clay	–	–	–	31.3	26.7	89

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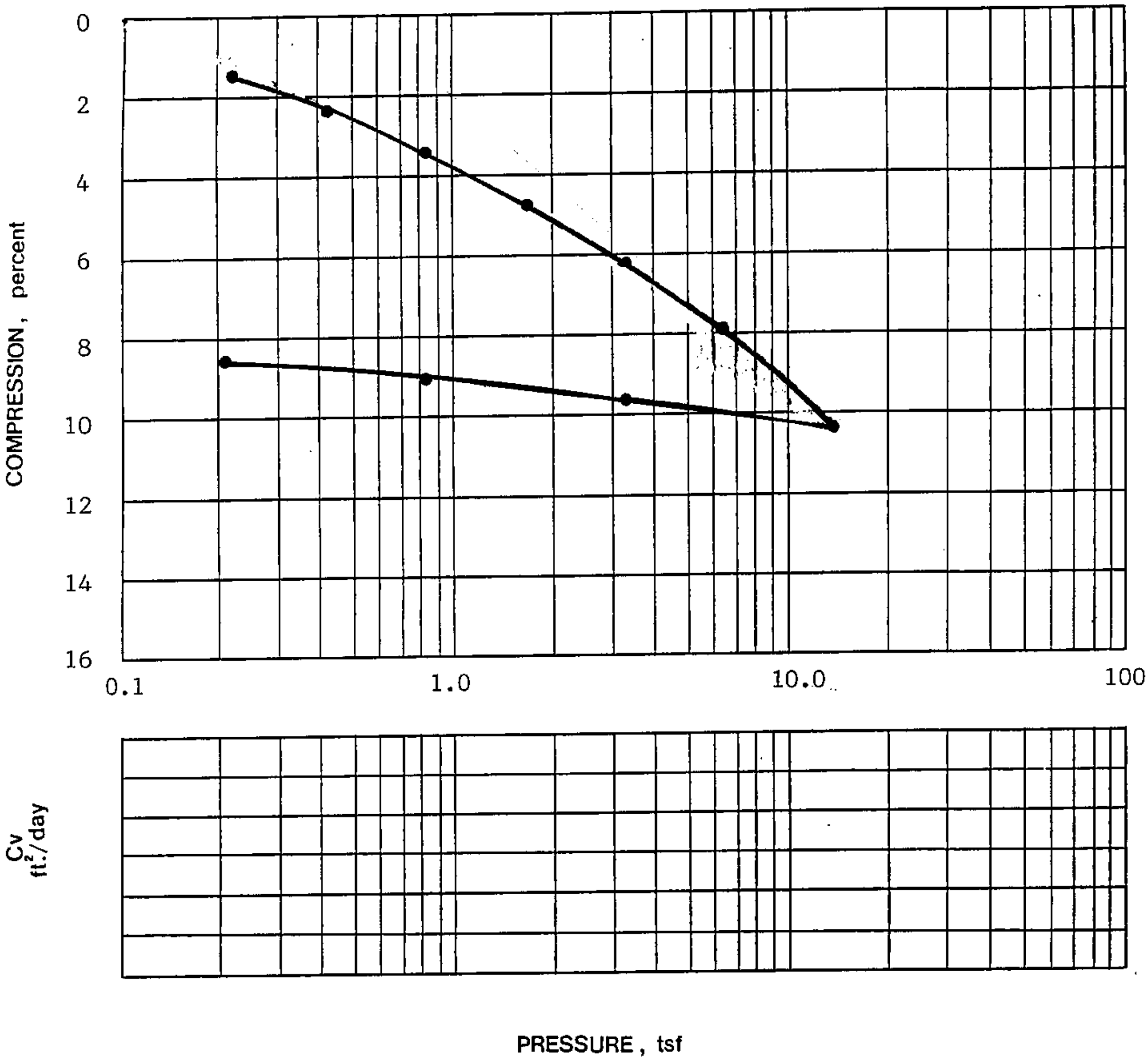
CONSOLIDATION TEST DATA

State Route 167 Bridges
Kent/Auburn, Wash.

Proj. No. 1630 | **Date** 10-91 | **Figure** B-23



Key	Boring No.	Depth (ft.)	USCS	Soil Description	Liquid Limit %	Plastic Limit %	Plasticity Index %	Moisture Content, W% Before	Moisture Content, W% After	Dry Density (pcf)
—•—	B-7	42.5	ML	Silt with CLAY	–	–	–	36.0	29.9	82

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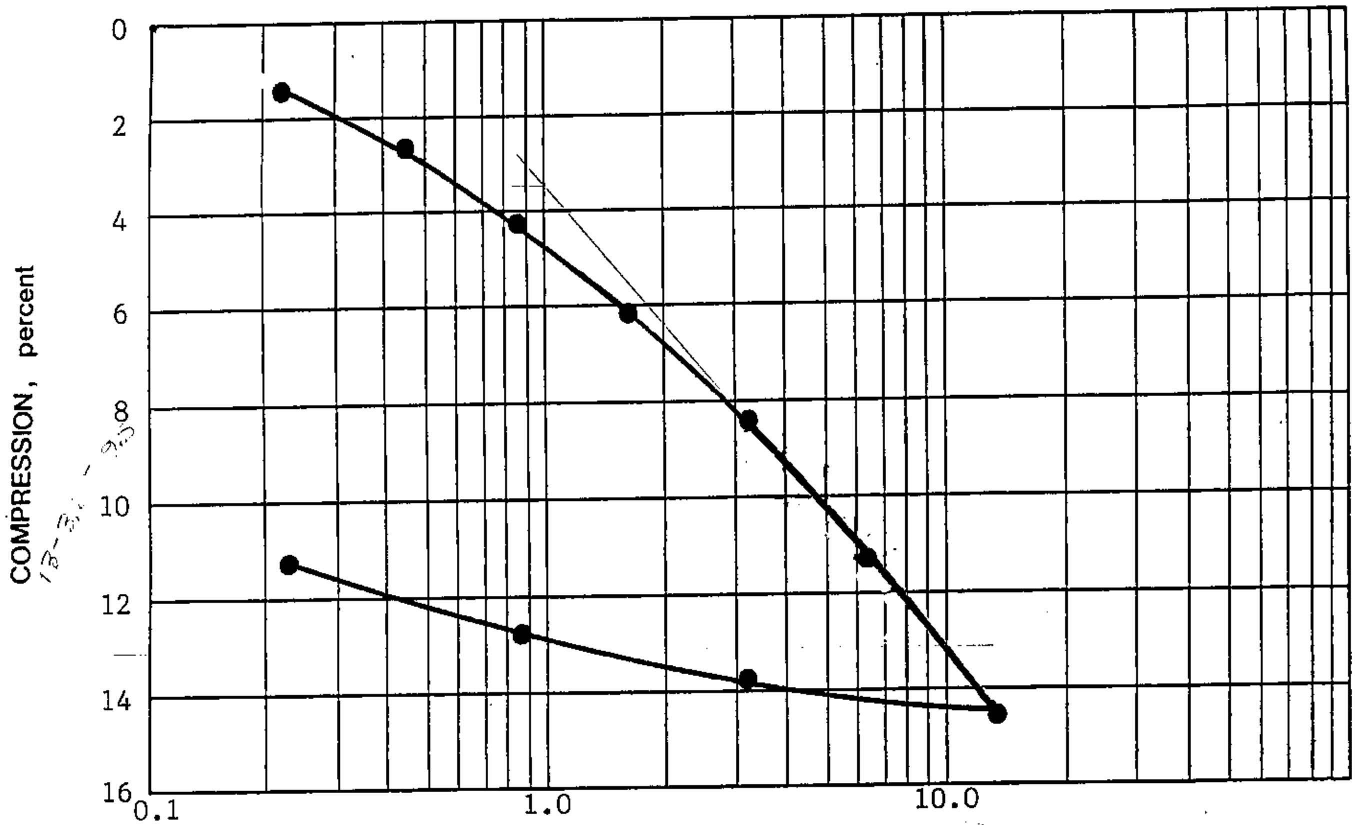
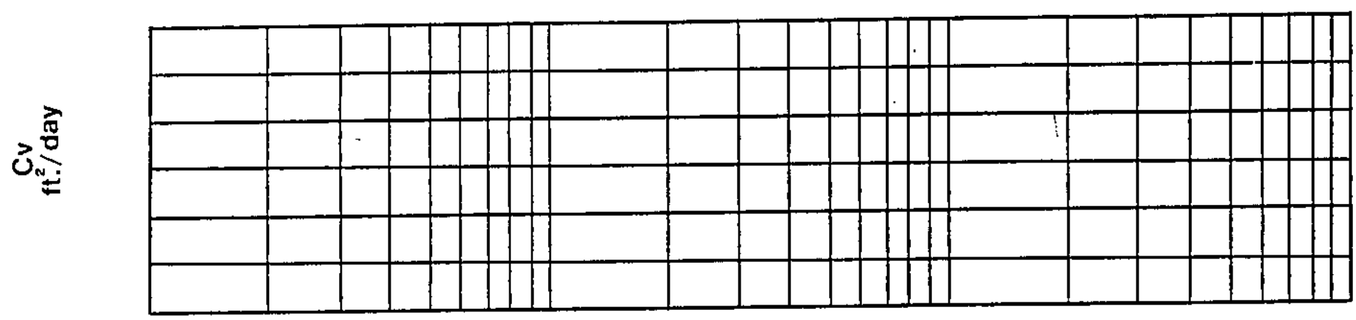
CONSOLIDATION TEST DATA
State Route 167 Bridges
Kent/Auburn, Wash.

Proj. No. 1630 | **Date** 10-91 | **Figure** B-24





PRESSURE, tsf

Key	Boring No.	Depth (ft.)	USCS	Soil Description	Liquid Limit %	Plastic Limit %	Plasticity Index %	Moisture Content, W % Before	Moisture Content, W % After	Dry Density (pcf)
—●—	B-9	42.5	ML	Sandy SILT, with clay	–	–	–	43.0	36.0	73

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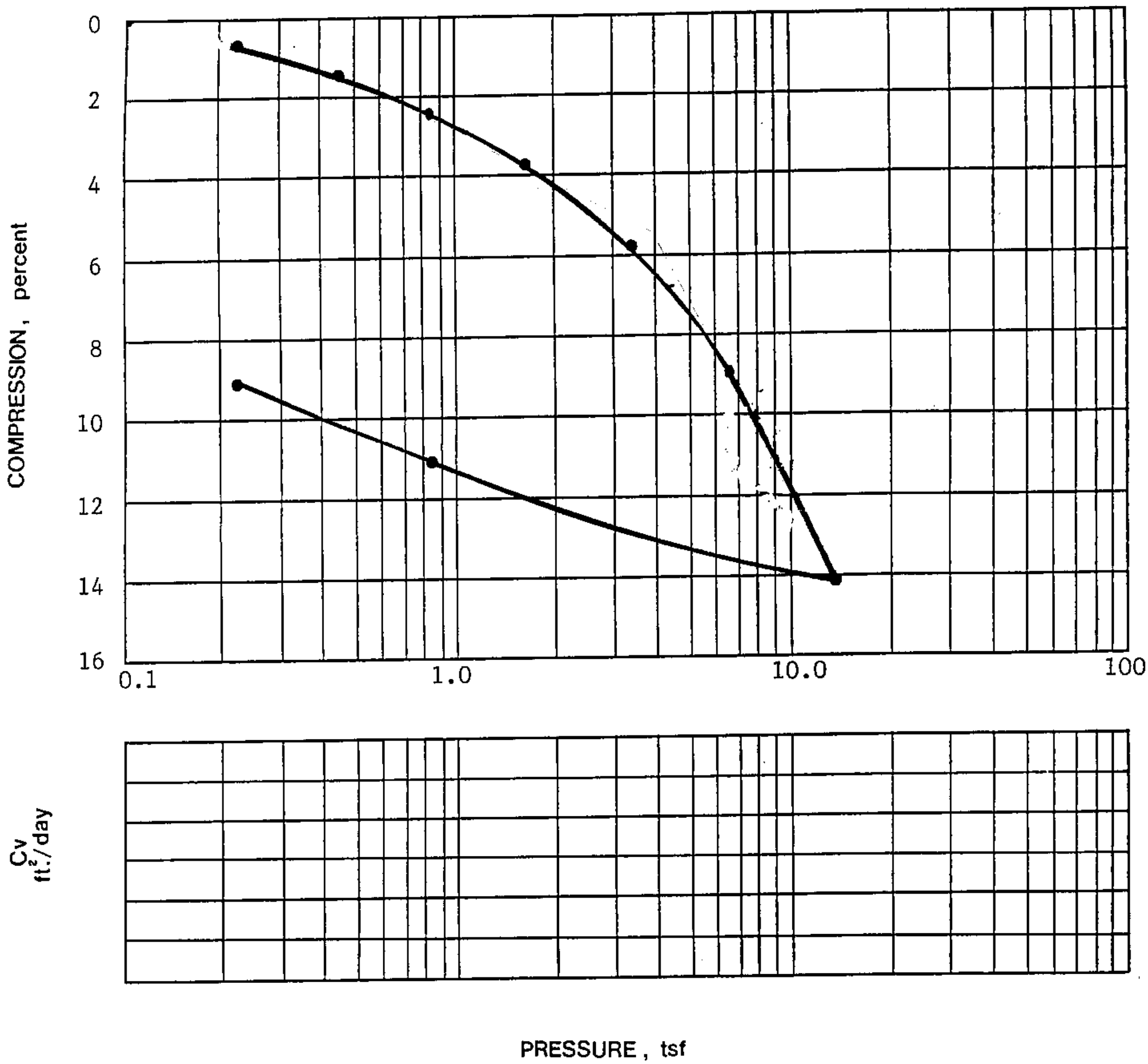
CONSOLIDATION TEST DATA

State Route 167 Bridges
Kent/Auburn, Wash.

Proj. No. 1630 **Date** 10-91 **Figure** B-25



Key	Boring No.	Depth (ft.)	USCS	Soil Description	Liquid Limit %	Plastic Limit %	Plasticity Index %	Moisture Content, W % Before	Moisture Content, W % After	Dry Density (pcf)
—•—	B-12	42.5	ML	Clayey SILT, scattered wood fragments	–	–	–	53.8	49.5	63.5

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CONSOLIDATION TEST DATA

State Route 167 Bridges
Kent/Auburn, Wash.

Proj. No. 1630 | **Date** 10-91 | **Figure** B-26